Science 20

MODULE 4

Biological Interactions

Distance Learning

Alberta EDUCATION

Science 20

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Alberta
EDUCATION

Distance
Learning

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Biological Interactions
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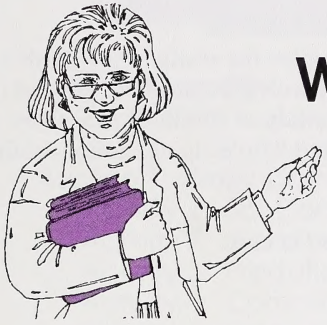


Welcome to Module 4!

We hope you'll enjoy your study of Biological Interactions.

To make your learning a bit easier, watch the referenced videocassettes whenever you see this icon.

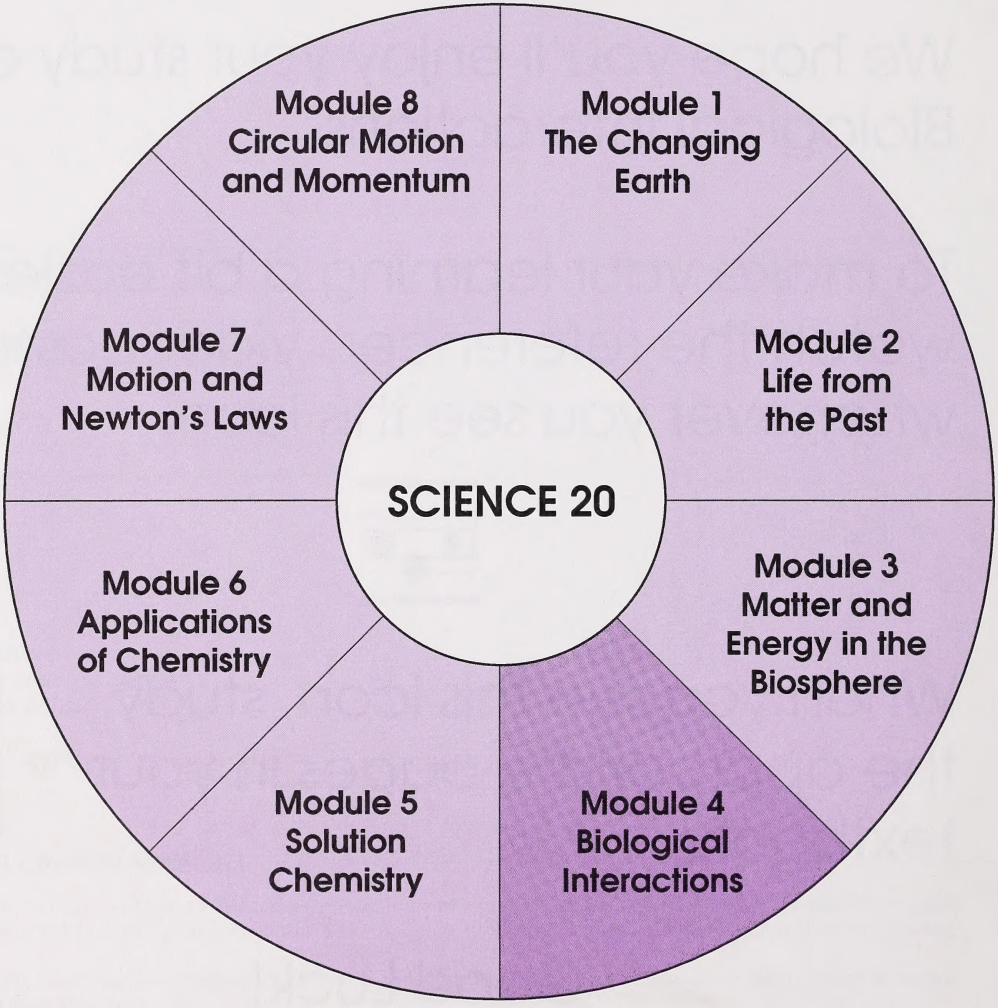
When you see this icon, study the appropriate pages in your textbook.

Good Luck!

COURSE OVERVIEW

This course contains eight modules. Modules 1 and 2 involve the study of the Earth's physical features and past life history. Modules 3 and 4 involve the study of life and its interaction with the Earth. Modules 5 and 6 involve the study of solutions as well as how chemistry is used for everyday things. Modules 7 and 8 investigate motion, both on Earth and in space.

The module you are working on is highlighted in a darker colour.



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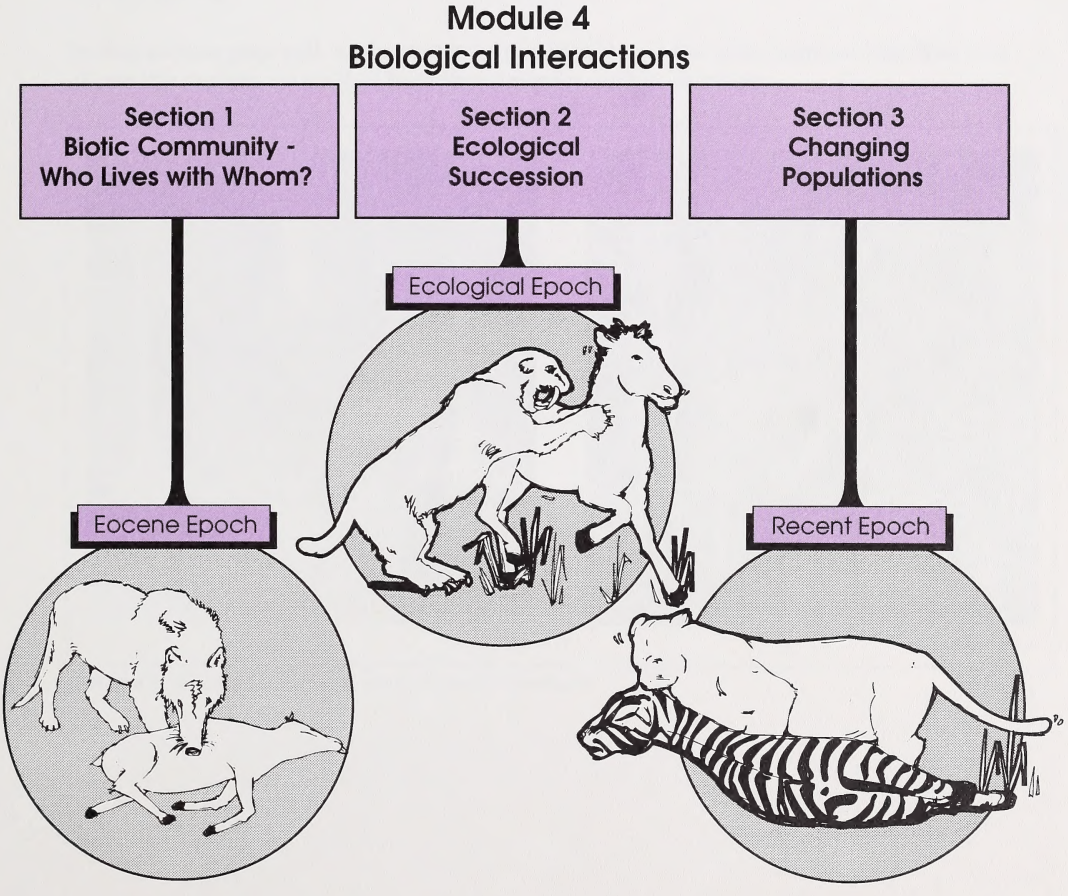
MODULE OVERVIEW

Have you ever thought about what it would be like to travel around the world? Imagine you just won ten million dollars and now get the chance to travel around the world to see and photograph much of the wildlife and natural wonders of the world. You would see countless animals, plants, and habitats. You would find a diversity of organisms living in harmony in an intricate balance. In some places you would see the impact of humans which has upset this delicate balance.

In Module 3 you studied that food chains and food webs show how organisms rely on each other for energy and material needs. In this module you will extend your study of the interaction of organisms, how they affect their environment, and the impact this has on their survival. You will also see how environmental conditions can select for specific traits in populations and cause change in the species over time. Drastic, rapid changes in environmental conditions can result in extinction when species are totally incompatible with the new conditions.



Evaluation

Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete three section assignments. The assignment breakdown is as follows:

Section 1 Assignment	**33 marks**
Section 2 Assignment	**32 marks**
Section 3 Assignment	**35 marks**
TOTAL	**100 marks**

Section

1 Biotic Community – Who Lives with Whom?

Can you think of any organisms that live or could live by themselves in the wild? You might think that producers could do this since they are able to meet their energy and molecular needs through photosynthesis. However, even they need other organisms to survive over time. Plants rely on decomposers to recycle essential elements and molecules for reuse from generation to generation. Many plants need a fungus to assist their roots in the absorption of soil minerals, other plants need the shade of larger plants, and still others actually grow on larger plants. Consumers and decomposers, on the other hand, surely cannot live alone for they rely on other organisms for their food and energy needs.

In this section you will study communities that live in the soil, communities that live above the surface, as well as how they interact with each other.

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FIGURE 4.1 An Urban Community and a Natural Community

Activity 1: Soil Community – A World Underground

Do you live in a rural or urban community? How active is your community league and what kinds of social activities does it organize? Does it produce a community newspaper? Is your community large enough to have its own radio station or television station? Obviously, the idea of a human community is familiar to you, but what about a biological or biotic community? Is this a special or different type of community than the one you live in?

1. Use your text, a dictionary, or any other resource to write the biological definition of the term *community* in your own words.

2. Examine the two communities in Figure 4.1 in the section introduction. Briefly explain the similarities and the differences between these two communities.

3. Identify several biological communities that can be found in your area.

4. The two biological terms community and ecosystem are often confused, but there is a very important difference. Briefly explain the difference between a community and an ecosystem.

Check your answers by turning to the Appendix, Section 1: Activity 1.

niche – the way an organism makes use of the biotic and abiotic resources in its environment, what it eats, how it gets its food, where it lives, and how it interacts with other organisms and its environment

In human communities there is a great deal of interaction among the individuals. Most members of a human community contribute to the survival of other members by providing a service or product. However, all members contribute to the community in a positive way. Thieves and muggers have a negative effect on other community members while a hermit may have little or no effect on others in the community. Similarly, the species of organisms that live together in a biological community contribute to the survival of other species or affect their welfare in some way. The role of each species in a community makes up, in part, the **niche** of that species. As is the case with human communities, not all of the interactions have a positive effect. Communities have boundaries, but these are generally not very distinct. In most cases one community will gradually blend into another and the zone of transition will include some species from both communities.

VISIONS

Study Figure 5.9 on page 169 of your textbook and read the caption below it. This will give you another perspective of communities and ecosystems.

5. What organisms make up the community shown in Figure 5.9?

6. What abiotic factors play a major role in determining what kind of community will develop and exist in a particular area? (You may have to check back to Module 3 to answer this question.)

Check your answers by turning to the Appendix, Section 1: Activity 1.

Now that you have a good understanding of the concept of community, it is time to look more closely at a real biotic or biological community found in the natural environment.

Science Skills

- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☐ F. Evaluating

Investigation: Soil Community: A Close-up View

In Module 3 you studied the composition of soil and how its physical properties affect the populations of plant and animal species. In this investigation you will study a community of organisms that make the soil their home.

Follow the directions of this investigation carefully. Pay special attention to the required components, safety aspects, and applied skills.

Purpose

In this investigation you will identify the organisms that make up a soil community and determine some interrelationships that exist among them.

PATHWAYS

If you can get a soil or leaf litter sample between late May and late September, then do Part A. If a soil sample is unavailable, then do Part B.

Part A

Materials

- shovel (spade)
- white enamel pans (or pan lined with white paper)
- small glass jars
- medium-sized glass jar (about 1 L)
- magnifying glass
- tweezers or forceps
- light microscope (optional)
- glass slides (optional)

- Berlese funnel (The funnel can be made from cereal box cardboard or a sheet of plastic. A hothouse hat can also be used.)
- identification keys (found at the end of the Appendix)
- soil (The soil sample should come from an undisturbed area and have a good layer of leaves or plant debris.)
- thermometer
- pH paper (with a pH scale)
- distilled water (available at most drugstores)
- window screen (20 cm × 20 cm)
- coat hanger wire or other stiff wire
- light source

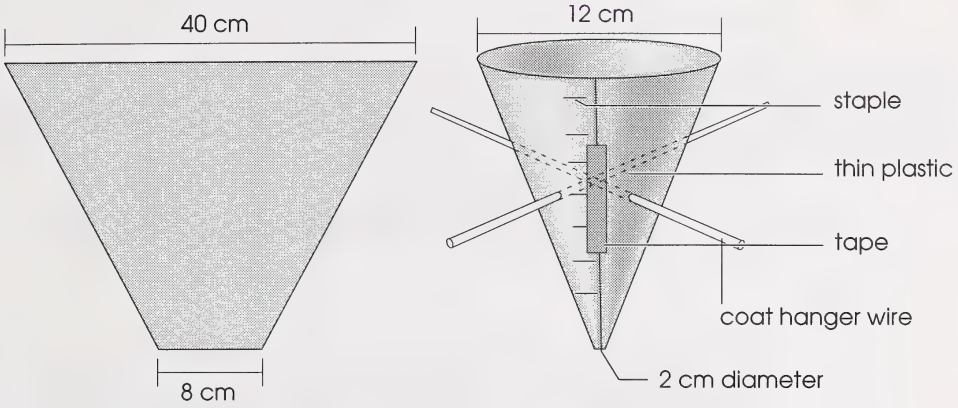
Procedure

- Read the planning section on page 170 of your textbook carefully. Make data charts like those in the Observations section of this investigation. Then do Step 1 on page 171. If you have a thermometer, pH paper, and distilled water, measure the soil temperature and the pH at the location where you take your sample.

- To measure the temperature, insert the thermometer about 10 cm into the soil. Take care not to break the thermometer. If the soil is hard or packed, loosen it before trying to insert the thermometer. Wait several minutes until the thermometer stabilizes; then read and record the temperature in your chart.
- To measure the pH of the soil, add enough distilled water to a small sample of soil in a small jar or glass so that it percolates down to the bottom and collects there. Move the soil aside and tilt the container so that the water collects into a pool into which you can dip a strip of pH paper. Read the pH off the scale provided on the outside of the pH paper container and record in your chart.

- Follow the procedure described in Steps 2 to 5 in your textbook. Do Step 6 if you have access to a microscope.
- The Berlese funnel can be set up as described in Skill 7 in the appendix of your textbook (page 534) or as described in the following three steps.

  Step 1: Approximately cut and shape the plastic or cereal box cardboard as shown in the following diagram.

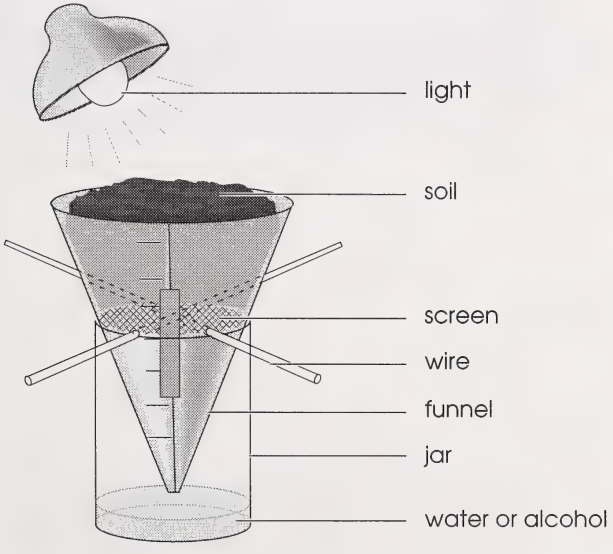


Step 2: Insert pieces of coat hanger wire through the funnel about half the distance between the top and the bottom.

Step 3: Cut out and lay the window screen on the wire. This is to keep the soil from falling through.

- Pour some alcohol or water into a medium-sized jar and set the funnel into the mouth of the jar. Pour the soil on the screen to a depth of 6 cm to 10 cm.

- To complete the setup, place the light source above the soil and turn it on. The light will dry out the soil, forcing the organisms downward until they fall through the hole at the bottom of the funnel and into the collecting jar.



Observations

7. With the aid of the identification key for soil litter found at the end of the Appendix, identify all the organisms collected. Use a chart like the one that follows and record the common names of the organisms and the number of each organism collected.

Temperature (°C)	pH

Common Name of Organism	Number Collected	Common Name of Organism	Number Collected

Remember that if you do not have access to a microscope, you will not see the large population of bacteria, fungi, and protozoans that also make up this community. Do not forget about them in the Analysis and Interpretation section.

Analysis and Interpretation

8. Answer questions 1, 3, 4, 5, 6, and 7 in the Analysis and Interpretation section on pages 171 and 172 of *Visions* 2.

Check your answers by turning to the Appendix, Section 1: Activity 1.

End of Part A

Part B

Materials

- sample data

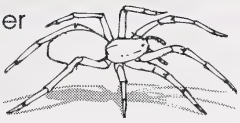
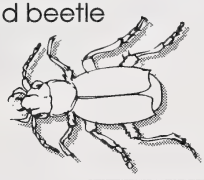
Procedure

- Use the following data obtained by a student doing the soil community analysis to answer the Analysis and Interpretation questions that follow the data. Pictures of the organisms found in the soil sample and the number of each are shown.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☐ F. Evaluating

Observations

Common Name of Organism	Number Collected	Common Name of Organism	Number Collected
ant 	6	spider 	2
mite 	15	slug 	1
beetle larvae 	1	grass 	30
roundworm 	100	earthworm 	5
harvestman 	3	clover 	1
centipede 	2	bacteria 	millions
ground beetle 	1	protozoans 	thousands
springtail 	12		

VISIONS

Analysis and Interpretation

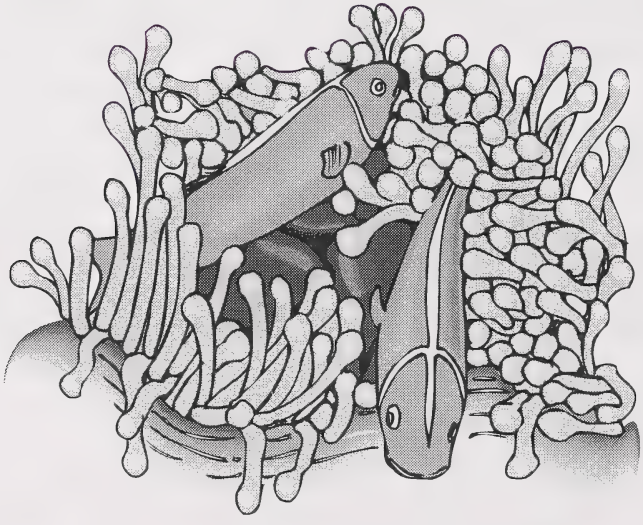
9. Answer questions 1, 3, 4, 5, 6, and 7 in the Analysis and Interpretation section on pages 171 and 172 of *Visions* 2.

Check your answers by turning to the Appendix, Section 1: Activity 1.

End of Part B

Through this investigation you have discovered the incredible diversity of life in the underground community of soil. In the next activity you will look at some special relationships between organisms.

Activity 2: Symbiosis



A small, brightly coloured clown fish swims about and then settles on the deadly stinging tentacles of a sea anemone. Suddenly it instinctively dives down among the tentacles of the anemone as a larger fish attacks it. The intruding larger fish makes unavoidable and fatal contact with the anemone's tentacles. A paralyzing poison shoots into the fish as the tentacles stick and wrap around it. The sea anemone has caught its next meal. The clown fish emerges unscathed and resumes its lazy routine among the deadly tentacles.

VISIONS

Turn to pages 172 to 174 of your text to read about the different types of **symbiosis** and answer the questions that follow.

1. Which type of symbiosis (**mutualism**, **commensalism**, or **parasitism**) would you use to describe the relationship between the clown fish and the anemone? Explain your choice.

2. What is one mutualistic organism that lives in humans. Explain the contribution that each makes to the relationship.

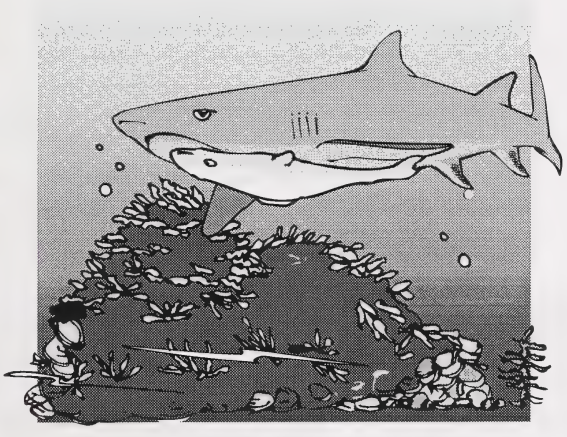
symbiosis – a close association of two organisms in which one or both benefit

mutualism – a relationship in which both organisms benefit from living together

commensalism – a relationship in which one organism benefits while the other is not affected

parasitism – a relationship in which one organism benefits while the other is harmed

Consider this next relationship.



A remora fish attaches itself to the belly of a lemon shark by means of a suction disc on the underside of its jaw. The shark swims about unperturbed and does not seem to be inhibited by the freeloader. When the shark makes a kill, the remora detaches from the shark and scurries about consuming the bits and pieces of prey strewn around as the shark goes about the messy business of ripping and tearing its prey into bits.

3. What type of symbiotic relationship exists between the lemon shark and the remora? Explain your answer.

In the next example imagine that you are on a beautiful island in the Caribbean for a holiday. A few days after you arrive, you develop stomach cramps and a severe case of diarrhea. The local doctor diagnoses your condition as amoebic dysentery, caused by an amoeba called *Endamoeba histolytica*. This protozoan is spread by infected human feces entering the food or water supply. Once inside your intestine, it consumes the intestinal lining, stripping away the layer which is essential in the absorption of nutrients you consume in food. If the organism is not destroyed, you will quickly dehydrate and succumb to the ravages of the intruder.

4. What type of symbiotic relationship do you have with the amoeba?

Check your answers by turning to the Appendix, Section 1: Activity 2.

As you can see, some organisms have developed quite a close relationship with another species of organism that lives in the same community. Such associations make life easier for one or both of the organisms and are so essential in some cases that the organisms could not live apart.

5. Explain how parasites can reduce the flow of energy through food chains.

6. Make a chart similar to the one that follows. Match the type of relationship in the chart with the correct organism pair and the correct effects listed in Columns A and B. Insert the name of the organism pair and the effect you choose in the proper space in your chart.

Column A

Organism Pairs

- cleaner fish and parrot fish
- robin nesting in a poplar tree
- fleas and dogs

Column B

Effects of Relationship

- Both organisms benefit.
- The host is harmed.
- One organism is unaffected.

Type of Symbiotic Relationship	Organism Pairs	Effects of Relationship
commensalism		
mutualism		
parasitism		

commensal – an organism that benifits in a commensalism relationship

7. A **commensal** and a parasite do not affect their hosts in the same way. How does the effect on the host differ?

8. Identify the type of symbiotic relationship in each of the following cases.

   a. Orchids live in the branches of trees in dense rain forests in order to get enough light. The trees are unaffected.

b. Flagellated protozoans live in the intestines of termites. The protozoans manufacture the enzyme cellulase which is needed to digest the wood eaten by the termites. The termite in turn provides the flagellates with a home and a food supply (wood). Neither can survive without the other.

c. A bumblebee feeds on the nectar of apple tree blossoms. It transfers pollen from flower to flower on its hairy legs.

d. A particular species of ant in Africa cleans the leaves of acacia trees by removing debris and vines. The ants live in colonies within the branches of the tree which they have hollowed out by removing some of the old non-functional wood. Here they farm scale bugs which secrete a sweet juice that the ants feed on. The scale bugs suck the juices from the acacia tree.

   What is the relationship between each pair of organisms?

   i. ant and acacia
   ii. ant and scale bug
   iii. scale bug and acacia

e. A farm dog is used by its master to herd sheep.

9. Explain why many parasites such as tapeworms produce such enormous numbers of eggs throughout their lifetime.

Check your answers by turning to the Appendix, Section 1: Activity 2.

You have looked at relationships which benefit both organisms involved, relationships in which the benefit to one organism causes harm to the other, and relationships in which one organism seems unaffected while the other benefits. In the next activity you will study the relationship between predators and their prey.

Activity 3: Predation – A Deadly Tie

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A large, hungry timber wolf stands frozen, ears cocked, sniffing the cold November air as it gazes at the trail of footprints in the snow. The wolf has picked up the scent of a mule deer that trespassed just minutes before. Letting out a long howl, the wolf breaks into a quick lope in the direction of its quarry. Shortly after, this wolf is joined by several other members of the pack and the pursuit intensifies. It is not long before the prey comes into view, a weary battle-scarred buck exhausted from a recent confrontation over mates. The buck is no match for the pack of predators. The wolves quickly bring the deer down and then spend the next several hours noisily filling their bellies with its flesh.

predation – the relationship between two organisms in which one uses the other as a food source

prey – an organism that serves as a food source for a predator

The relationship between the wolf and the deer is called **predation**. When you think of predators, animals such as wolves and cougars may come to mind. These animals attack and kill their **prey** in order to eat. The predator-prey relationship, however, can also include herbivores that eat plants and plants that eat animals. Some sources of information expand the definition of predation to include herbivores while others limit the definition to include only meat-eating organisms.

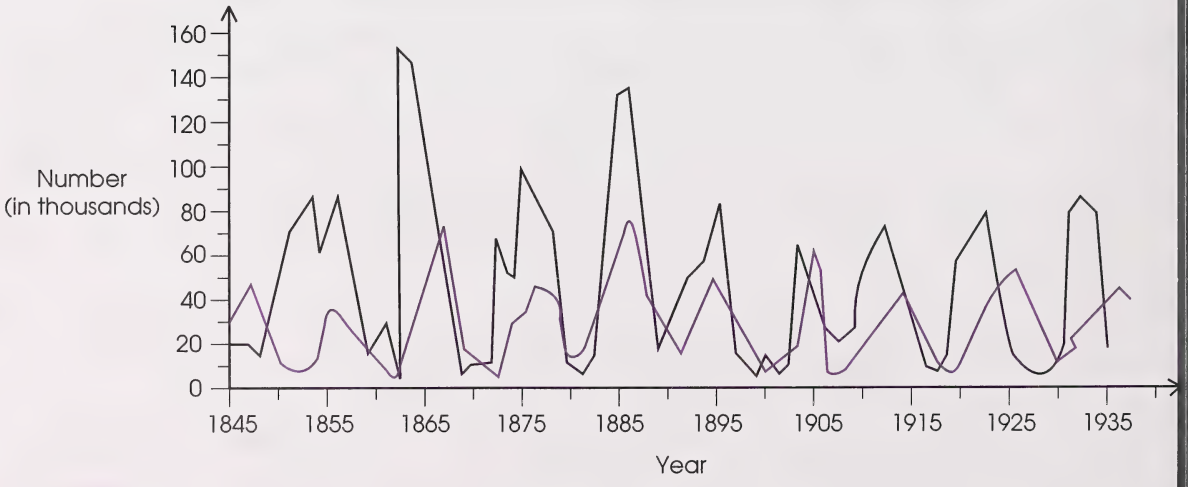
VISIONS

To learn about these different types of predator-prey relationships, read the section on predation on pages 174 and 177 of your *Visions 2* text and answer the questions which follow.

1. How does the text define predation?

2. Predation is an important biotic factor in an ecosystem balance. Explain this statement.

3. Study the following graph showing the populations of a predator and its prey.



a. Which line represents the predator?

b. Which line represents the prey?

c. How can you tell?

d. If you had been a trapper between 1845 and 1935, what approximate year would have been the most productive for the fur of these two animals?

e. What is the reason for the delay in the rise in predator numbers in each cycle compared to the prey population?

f. What appears to be the average length of the cycle of high to low populations for both the predator and the prey?

Check your answers by turning to the Appendix, Section 1: Activity 3.

It is quite obvious that the predator benefits in the relationship shown in the following cartoon while the prey is harmed.

[1]

[1] *The Far Side* cartoon by Gary Larson. Far Side copyright 1986 Farworks, Inc. Reprinted with permission of Universal Press Syndicate. All rights reserved.

Science Skills

- ☑ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☑ F. Evaluating

Investigation: Predator-Prey Relationships

Pay attention to the required components, safety aspects, and applied science skills.

Purpose

In this investigation you will carry out a simulation of a predator-prey interaction to show how one affects the number of the other. You will also have to develop several hypotheses to explain what happens when you change a factor in this scenario. You can test your hypotheses using appropriate variations of the method spelled out in the procedure.

Materials

- an assistant (if you cannot work in a group)
- 1 envelope
- 4 pegs
- 16 m of string
- a watch with a second hand
- 200 to 300 toothpicks or narrow strips of coloured paper
- food colouring or water colours

The toothpicks or coloured paper will represent the prey in this simulation and their colours will depend on the colour of the surface on which this activity is done. Choose one of the following:

Location	Toothpicks or Coloured Paper Strips
green lawn	50 forest green (dark green), 50 kelly green (medium green), 50 grass or olive green (light green), and 50 natural colour
brown lawn	50 natural colour, 50 brown, 50 black, and 50 green
shag rug	50 of the colour of the rug, 50 of a shade of this colour, 50 of a contrasting colour, and 50 of a complementary colour

Procedure

Step 1: If you are using toothpicks, dye the toothpicks with food colouring or solutions of water colours. To get lighter shades of a particular colour, dilute with more water or leave them in the solutions for less time. Remember that you will likely lose some toothpicks after a trial, so dye extra ones of each colour. If you are using coloured paper, cut the paper into strips about 5 cm long and 2 mm wide.

Step 2: Mark out a 4 m by 4 m area on your lawn or rug. Have your assistant mix and scatter the 200 toothpicks or strips of coloured paper of various colours over this area while you look the other way. The toothpicks or coloured paper may have to be shortened or worked into the rug somewhat so that they are not too obvious. This should not be a problem on grass.

Step 3: Your assistant will give you two minutes to find as may toothpicks or strips of paper (prey) as possible.

Place the toothpicks or coloured paper in the envelope as you find them during your hunt.

Step 4: After the hunt, sort the toothpicks or coloured paper found according to colour and record the number of each.

Step 5: Repeat the procedure and average the counts. Record the average in a chart like the one in the Observations section of this investigation.

VISIONS

Step 6: Refer to Step 5 in the Procedure section on page 176 of *Visions 2*. Formulate a hypothesis for at least two of the questions given in Step 5. Test your hypothesis by changing the number of toothpicks or strips of coloured paper as required and repeating Steps 3 to 5 in the Procedure section of this investigation.

Observations

4. Make a chart similar to the one that follows; then, record your data in the chart.

Toothpicks	Number of Toothpicks (Prey) Found		
	Average of Initial Hunt	Average Results of Hypothesis One	Average Results of Hypothesis Two
forest green (dark green)			
kelly green (medium green)			
grass or olive green (light green)			
natural colour of toothpicks			
total (all colours)			

5. Write out a hypothesis statement for each question you picked.

6. Write out an assessment of your test of each hypothesis in terms of predator-prey relationships.

Analysis and Interpretation

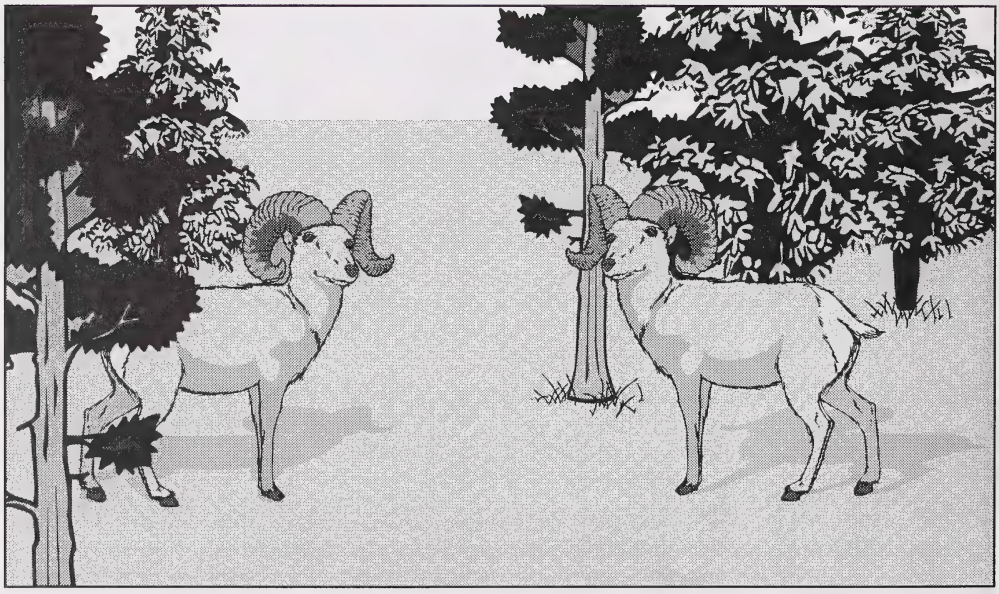
7. Answer questions 1, 2, and 4 in the Analysis and Interpretation section on pages 176 and 177 of *Visions* 2.

Check your answers by turning to the Appendix, Section 1: Activity 3.

If you have access to the video entitled *Communities*, from the *Ecology* series, you may wish to watch the video for a review of Activities 1, 2, and 3. Pay particular attention to the predator-prey relationships and the symbiotic relationships. This video may be purchased from Learning Resources Distributing Centre.

You have discovered the nature of predator-prey relationships. Now you are ready to study competition.

Activity 4: Competition – The Ultimate Challenge



Two bighorn sheep rams stand some distance apart facing each other. Suddenly they lower their heads and charge. There is a resounding clunk as heads and horns crash together bringing the two animals to a sudden halt. Slowly they back up, heads cocked forward, until they have moved to their original positions. They lift their heads and stare at each other for a few minutes. Then suddenly, without warning, they rear up and charge again. This continues until one of the animals finally seems to be overwhelmed by the encounter and leaves. This scene is common in the autumn during the breeding season when the rams are establishing their territory and competing for mates. Many species compete with each other for resources in their environment. The less there is of a particular resource, the more severe the **competition** and consequences become. Organisms may compete for such resources as space, food, light, water, and mates.

competition – the relationship between two or more organisms when there is a limited amount of resources available

FIGURE 4.2 Intraspecific Competition and Interspecific Competition

intraspecific competition – competition between organisms of the same species

interspecific competition – competition between organisms of different species

In Figure 4.2 **intraspecific competition** is illustrated by the aspen poplar trees that compete with each other for space, light, water, and minerals in the soil. **Interspecific competition** is illustrated by the different species of hawk that compete for food.

VISIONS

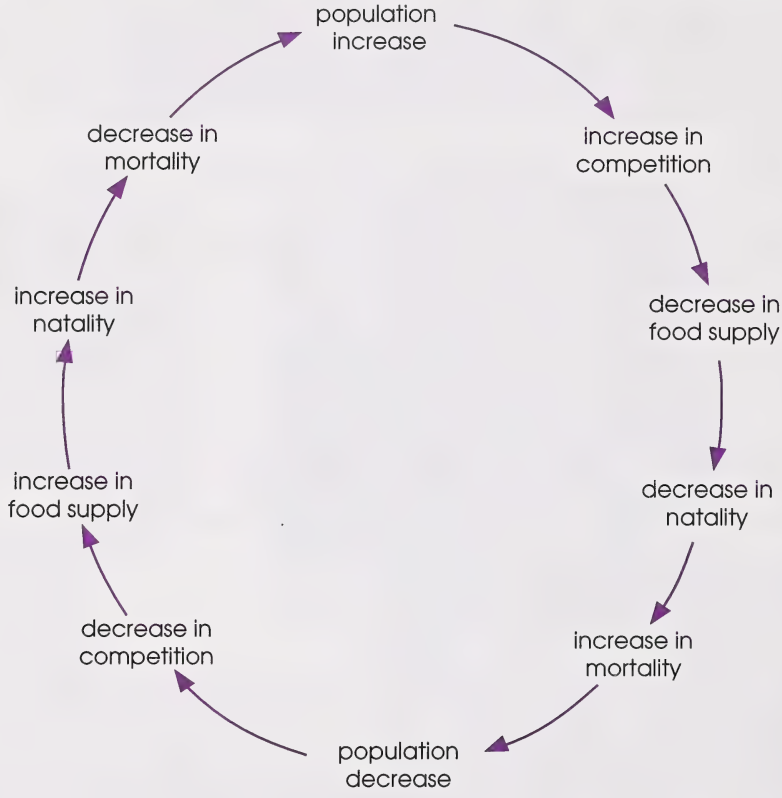
Read pages 178 to 180 of *Visions 2* and use what you have learned about competition to answer the following questions.

1. Some species of larger carnivores like the grizzly bear are solitary and have very large territories to reduce intraspecific competition. Other carnivores like the wolf also have a large territory, but they stay together in family groups or packs. What survival advantage is there for wolves forming their packs which offsets the disadvantage of intraspecific competition?

2. The following competition model of population regulation (stress model) illustrates how an increase in population causes stress for the individuals in the population. A population increase successively leads to increased competition, decreased food supply, decreased **natality**, increased **mortality**, and ultimately a decrease in population size. A population decrease successively reduces competition, increases food available to individuals, and leads to increased natality and decreased mortality, which allow the population to increase again.

natality – the birth rate in a population

mortality – the death rate in a population



a. Apply this model to a snowshoe hare population in Alberta to show how competition among members of the population causes a cyclic rise and fall in their numbers. Describe the cycle in a short paragraph. Begin with an increase in food supply.

b. What role does predation play in this cycle?

3. What resource are the organisms competing for in each of the following examples?

a. Two bighorn sheep rams back up, lower their heads, and charge each other. This clashing of heads continues until one is defeated and driven off by the victor. This behaviour occurs for several weeks in the fall.

b. Two foxes stalk the same ptarmigan.

c. One grizzly bear attacks and drives off another young grizzly bear that seems to be passing through the area. There is no apparent reason for the attack.

d. An aspen poplar sapling is growing under two mature spruce.

e. A coyote lunges at a magpie which has just landed near a deer carcass the coyote is feeding on.

4. Many animals are territorial; they need a certain amount of space. How do the following animals proclaim their territory so that others do not intrude?

   a. aphids
   b. male spruce grouse
   c. wolves

5. When the niches of two species overlap, there may be interspecific competition. Explain this statement.

Check your answers by turning to the Appendix, Section 1: Activity 4.

Activity 5: Exotic Species – Community Intruders

In 1859 the European rabbit was introduced into Australia for sport. The decision to bring over a familiar animal from the homeland seemed innocent enough; besides, what harm could these long-eared hoppers possibly do in this strange land down under? However, once released, the rabbits multiplied explosively because they had no significant natural predators in this new land. Over the next few decades the intruder spread over the entire continent and its population reached into the millions. Rabbits competed with kangaroos, cattle, and sheep for grasses and other forage plants. In 1950 the disease myxomatosis which is caused by a virus, was brought over in an attempt to control the introduced pest. It had devastating effects, wiping out almost the entire population. Only the naturally resistant ones survived.

The previous example illustrates the intricate set of checks and balances in natural communities which regulates the size of populations. As you discovered in the first four activities, predation and competition help to control population size. Parasites weaken hosts and make them more susceptible to predation, while mutualistic and commensalistic symbiosis help some organisms to survive. This natural self-regulating system can be easily unbalanced by the accidental or deliberate introduction of a new species of organism. The intruder becomes an unnatural predator or competitor, and if aggressive or tenacious, it will cause the populations of affected natural species to decline because of the niche overlap. Equally as serious is the possibility that the new organism may not have any natural enemies in its new environment such that its numbers will explode very quickly.

VISIONS

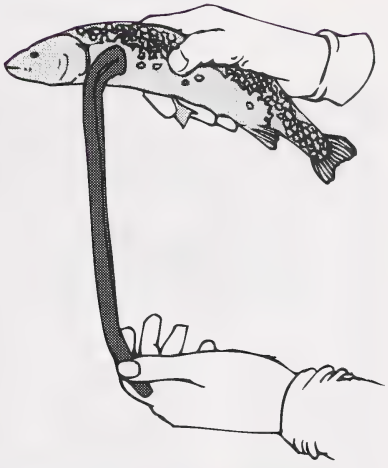
Read the case study called Zebra Mussels in Canadian Waterways on page 178 of *Visions 2* and review the major points by answering the following questions.

1. The zebra mussel is an exotic species introduced into Lake St. Clair. What effects has it had on the ecosystem?

2. The zebra mussel is expected to continue to expand its territory. What abiotic factors will limit this expansion?

3. The mussel has the potential to cause major economic and ecological problems in its new ecosystem. Identify one problem of each type.

Check your answers by turning to the Appendix, Section 1: Activity 5.



Many other species have been introduced to various parts of the world where they have not existed previously. One such species is the sea lamprey which gained access to the Great Lakes through the construction of the Welland Canal.

4. Research and write a case study about the effects of the lamprey on the ecosystem once it gained entry to the Great Lakes.

Check your answers by turning to the Appendix, Section 1: Activity 5.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment. You may do both.

Extra Help

Organisms in nature live together in communities and rely on one another for various reasons.

1. Provide three possible reasons for the formation of communities.

2. Using organisms you have studied in this section, give one example of each reason listed in your answer to question 1.

The range of species making up a community, from the microscopic bacteria to the large plants and animals, is determined by the abiotic factors of the region. Communities can be large or small with distinct boundaries as in the case of a pond, but in most cases communities have fuzzy boundaries and gradually blend into one another.

To increase their chances of survival, many organisms have formed close associations with other species, taking advantage of a certain available food source or the protection that is offered. Such relationships collectively are known as symbiosis.

3. There are three types of symbiosis. Make and complete a chart similar to the one that follows. One has already been done for you.

Type of Symbiosis	Description
parasitism	relationship in which one organism benefits while another is harmed

Predation and competition are two factors that control population size of community members and help to maintain community stability. This can be disrupted by the introduction of an exotic species that is an unnatural competitor or predator which causes a decline in the natural species affected. The impact of the intruder is most serious when it does not have any natural enemies and its numbers quickly explode out of control.

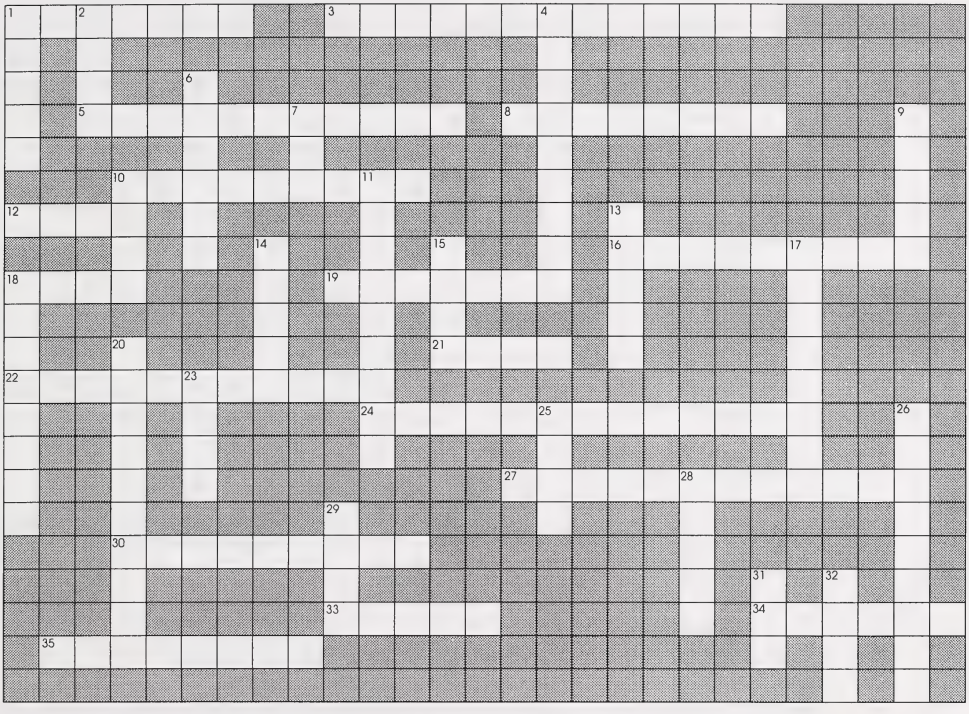
Do the following questions to complete your review of important concepts from Section 1.

4. Make a chart similar to the one that follows. For each ecological relationship indicate the effect on the two organisms involved. Use the following symbols:

   + = benefits from relationship
   − = harmed by relationship
   0 = no effect

Ecological Relationship	Effect on Organism 1	Effect on Organism 2
mutualism between 1 and 2		
parasitism by 1 on 2		
commensalism of 1 on 2		
predation by 1 on 2		
competition between 1 and 2		

5. Complete the following crossword puzzle using words you have encountered in this section.



Across

1. to strive for resources others need
3. competition between species
5. organism's surroundings
8. parasitic worm of the intestine
10. relationship in which both organisms benefit
12. information
16. photosynthesizers
18. a cone-bearing tree
19. non-living components of the environment
21. general term for what is eaten
22. organisms that reduce dead organic matter into simple reusable molecules
24. competition between members of the same species
27. relationship in which one organism is unaffected while the other benefits
30. area or space an organism considers to be its own
33. solar energy used by producers
34. introduced organism, an intruder from another part of the world
35. organism that must eat

Down

1. a series of links as in energy flow through a part of a community
2. to change position or location
4. a relationship in which one organism benefits while the other is harmed (adj.)
6. the living components of an ecosystem (adj.)
7. word meaning none
9. an extremely small parasite which causes the common cold
10. partner of the opposite sex specifically for reproduction
11. general term for a close association between two organisms
13. area needed for survival
14. the product of decomposers
15. predator whose effectiveness is increased by hunting in packs
17. a regular change as in a rise and fall of a population (adj.)
18. organism that kills and eats another
20. the collective term for all the individuals of the same species living together in one area
23. organisms eaten by predators
25. a form of precipitation
26. all species of organisms living together and interacting in a certain area
28. how an organism makes its living and interacts with other members of its community and its environment
29. mixture of rock particles and humus
31. interconnected food chains
32. organism which supports a parasite or a commensal

Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

PATHWAYS

If you have access to a laboratory and fresh fish, do Part A. If you do not have such access, do Part B.

Part A

Investigation: The Fish Tapeworm

Science Skills

- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☐ F. Evaluating

One common group of endoparasites are the many species of tapeworm. Tapeworms occur in most carnivores and omnivores including humans, and they are readily available from freshwater fish such as walleye and northern pike.

Purpose

In this investigation you will extract tapeworms from a local fish you have caught or bought in order to study their general features and to learn more about their life cycle.

Materials

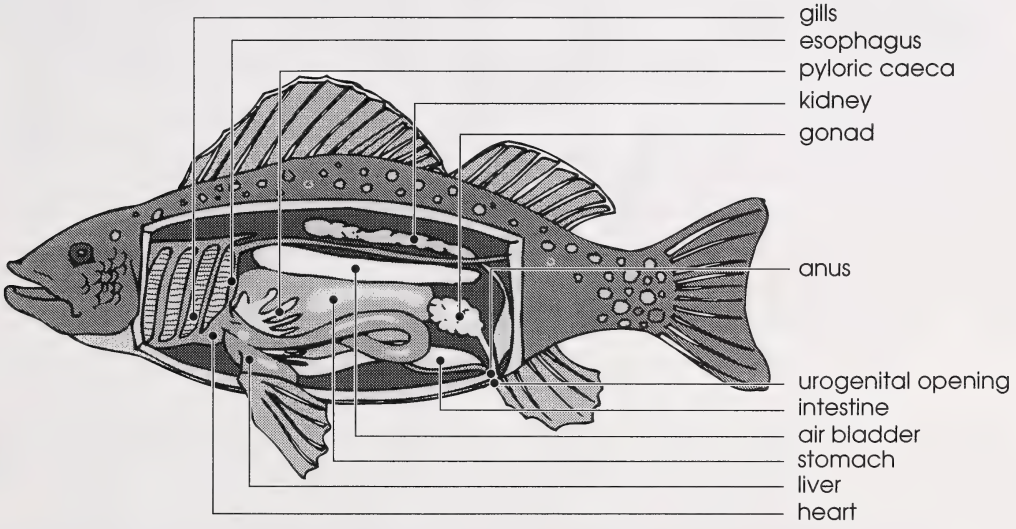
- one walleye or northern pike
- filleting knife
- stereoscope or microscope (if available)
- petri dish or small, shallow glass bowl
- surgical gloves
- scissors
- hand lens
- tray
- alcohol
- forceps (tweezers)

Procedure

Caution

It is advisable to wear surgical gloves to avoid getting any tapeworm eggs on your hands. It should be noted that if you were to accidentally consume some of these eggs, they might hatch but would not survive.

Step 1: Lay the fish on a filleting board and cut the belly open or remove a fillet to expose the entrails.



Step 2: Cut out the intestine from the anus to the stomach and lay it in a tray of water.

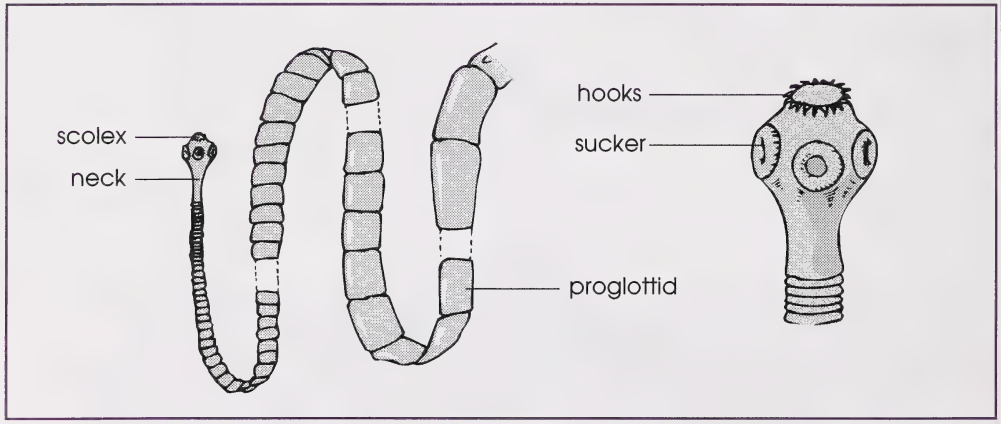
Step 3: With a pair of scissors or the knife cut open the intestine from one end to the other. Wash out the tapeworms and discard the intestine.

Step 4: Count the number of worms and get an approximate measurement of their length. Notice the undulatory movement of the worms.

Step 5: Using a hand lens, look closely at the flat nature of the worm and its many segments. Notice that the segments become larger toward the back end of the worm. The very end segments are mature and full of eggs. They are ready to break away and be expelled to the outside with the wastes.

Step 6: Transfer one worm into the petri dish and immerse it in an alcohol solution to immobilize it.

Step 7: Look at the head with a hand lens or stereoscope. Can you make out the suction discs and the hooks? These are used to secure the worm to the wall of the intestine so that it doesn't slip out of the intestine as food is moved through. There is no mouth nor is there an intestine further down. The parasite simply absorbs nutrients through its skin as the host animal digests its food.



Analysis and Interpretation

1. Describe the physical features of the tapeworm that allow it to thrive in the intestine.

2. The process by which the tapeworm absorbs its nutrients is called diffusion. Describe how this process works. (You may have to look in other books to find the answer.)

3. Tapeworms are very similar to the earthworms you studied in Science 9 in the way they reproduce. Both types of worms are said to be hermaphroditic. What does this mean? How does this describe the tapeworm's method of reproduction?

4. How does the worm release its eggs?

5. Why doesn't the worm get digested like the food the host eats?

Check your answers by turning to the Appendix, Section 1: Enrichment.

End of Part A

Part B

You, along with other people in your area, are part of a human community as well as the larger biological communities that exist there. In this activity you will take a critical look at the impact people have had on the biological communities in your area.

6. Make a chart similar to the one that follows. Consider each of the organisms and its habitat by indicating the ecological relationship between it and humans, how its population has been affected by humans, and what specifically humans have done to cause a change in numbers.

Organism	Habitat	Ecological Relationship with Humans	Human Impact on Population	Human Activity Causing Change in Organism Population
mallard duck	slough			
aspen and spruce	forest			
ground squirrel (gopher)	grassland			
whitetail deer	mixed forest and open grassland			

Check your answers by turning to the Appendix, Section 1: Enrichment.

End of Part B

7. Research and write a case study about the effects on the ecosystem of one of the following.

    - the starling, the Argentine fire ant, or Dutch elm disease introduced to North America
    - the fox introduced to Australia
    - the mongoose introduced to the West Indies

Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

In this section you have discovered that organisms cannot survive alone and so they must live together in communities. Within these communities each species of organism occupies a specific niche as a producer, a consumer, or a decomposer. You have learned that all the member species, in one way or another, contribute energy and matter for future use. You have also discovered that the reliance of organisms on others for various needs has resulted in a number of highly specialized associations such as parasitism, commensalism, and mutualism, all of which collectively are known as symbiosis. Some organisms are not involved in a symbiotic relationship, but their interactions with other organisms are still essential. Such is the case with predation in which predators must have prey to survive. Predation, in turn, helps to keep prey populations in check so that the prey species does not reach such high numbers that it harms or destroys its own food source or the environment that sustains it. You have also considered the element of competition between members of the same species and individuals of different species. Competition for limited resources such as food and space contributes to a struggle for existence and is reflected in a regular rise and fall in numbers as the competition increases or decreases. Finally, you have studied the impact of a species introduced to a community. In most cases the intruder has a negative and sometimes devastating effect on one or more of the natural community species.

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

Section

2 Ecological Succession

Imagine driving through the charred smoldering remains of a forest destroyed by fire the night before. You are transfixed and dismayed by the sight. Except for an isolated tree here and there and patches of sphagnum moss, little life remains. Where a mature thick stand of spruce and pine stood the day before, thin blackened poles of tree stems now stand as silhouettes against the sky. Wisps of smoke rise from the embers of burned trees. The landscape seems naked and exposed! What now? If nature is left to its own devices, what will eventually happen in this area of devastation? Will the plant and animal life come back?

ALBERTA FOREST SERVICE

You may have noticed that an abandoned lot or field, if left untouched for an extended period of time, does not remain in its original state. It may start out as a grassy area but soon it will become overgrown with weeds. As time passes, taller weeds dominate the shorter ones, and in a few years small saplings and shrubs appear. If you could watch for the next hundred years, you would witness one of nature's most remarkable processes – ecological succession.

In Section 1 you discovered that organisms live together, forming stable biological communities. In this section you will see that communities undergo change. You will develop an understanding of ecological succession and why it occurs. You will also see that this process will occur in an area where no community existed before or whenever a community has been disturbed either by human activity or by a natural catastrophe such as fire or a volcanic eruption.

Activity 1: Succession Observed

Although life is delicate, it is tenacious and persistent. If a catastrophe such as the eruption of Mount St. Helens completely destroys the living things on its slopes, life will reestablish there given time. It will eventually return to the stable community that existed there before the catastrophe. The same general process of regeneration occurs in burned-out and logged areas where grasses and weeds first reappear and are eventually replaced by trees. This process occurs in aquatic communities as well.

VISIONS

Read pages 182 and 183 of *Visions 2* for an example of **succession** as it occurred on the island of Krakatoa in Indonesia. Then answer the next three questions.

1. Draw a flow chart to show the sequence of organisms that eventually reestablished themselves on the island of Krakatoa after the volcanic eruption. Start with the spider.

2. What kinds of plants took root once the soil became thicker and richer?

3. Define *ecological succession*. Make reference to the climax state in your definition.

succession – the gradual replacement of one community by another until a stable climax community becomes established

Check your answers by turning to the Appendix, Section 2: Activity 1.

Science Skills

- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☑ F. Evaluating

Investigation: Establishing a Microenvironment and Observing Succession

PATHWAYS

If you have access to laboratory facilities, do Part A. If you do not have access to laboratory facilities, do Part B.

Part A

Purpose

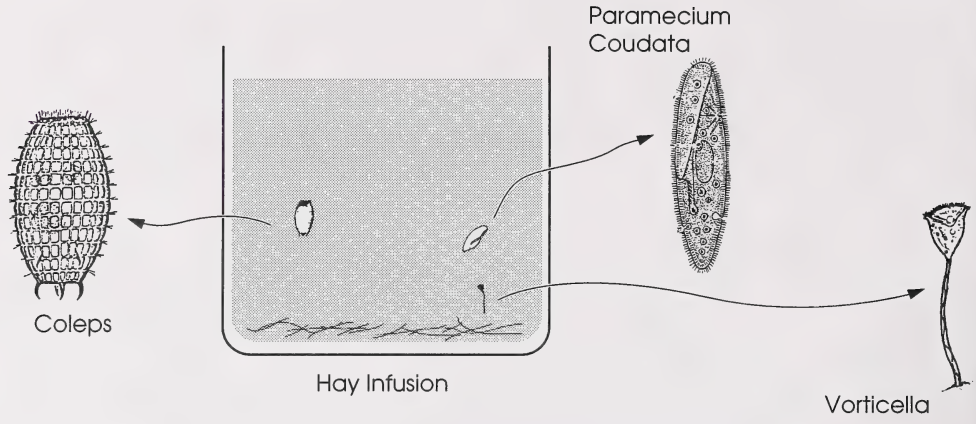
Succession in a large ecosystem is a slow and gradual process which often would not be completed in your lifetime. In this activity you will use a microenvironment to observe succession over a short time period.

Materials

- The required materials and equipment are listed in Activity 5.5 Observing Succession on page 183 of *Visions 2*.
- You may use large tin cans with the tops removed or wide-mouthed jars if beakers are unavailable.
- Instead of distilled water, rain water or melted snow may be used. Chlorinated well water or tap water could be used as long as it sits for two or three days to remove the chlorine before use in the investigation.
- A pipette can be used instead of an eyedropper.

Procedure

- Follow Steps 1 to 4 outlined in Activity 5.5 on pages 183 and 184 of your textbook.
- Step 4 of the procedure should involve the removal and analysis of a water sample from the top, middle, and bottom of the beaker each time you test the hay infusion. Be careful not to mix the layers in your container. Put two drops of the infusion on your slide each time so that the relative population counts come from the same volume throughout the investigation.
- Using the index of common micro-organisms provided in the Appendix, proceed with the identification of organisms as they appear over the next five days.
- Make a data chart similar to the first one in the Observations section. List all the organisms you identify by common name or scientific name. Record the actual or estimated number (if there are too many to count) of each organism for each day you make observations. Approximate numbers of aerobic and anaerobic bacteria have been included for you.
- Make a data chart similar to the second one in the Observations section. Record the temperature and the colour of the hay infusion in your data chart for each day observations and measurements are done.



Observations

4. Record your data in your chart.

NAME OF ORGANISM	NUMBER OF ORGANISMS EACH DAY							
	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Day8
Bacteria: Aerobic Forms Anaerobic Forms	4.1×10^3 3.7×10^2	8.7×10^3 7.5×10^2	1.3×10^4 1.5×10^3	1.2×10^4 1.9×10^3	9.6×10^3 4.2×10^3	8.1×10^3 7.9×10^3	4.7×10^3 1.4×10^4	1.2×10^4 2.0×10^4
Blue-Green Algae:								
Green Algae:								
Protozoans:								
Diatoms:								
Rotifers:								
Misc. Invertebrates:								

5. Using the following legend of colour, record your data in your chart.

Legend of Colour
C = clear
B = amber
G = green

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Colour								
Temperature (°C)								

Analysis and Interpretation

VISIONS

6. Answer questions 1 to 7 in the Analysis and Interpretation section on page 184 of your textbook.

Check your answers by turning to the Appendix, Section 2: Activity 1.

End of Part A

Part B

Purpose

In this investigation you will analyse the data collected by an Alberta student who observed succession in the microenvironment of a hay infusion.

VISIONS

To put the observations into context, read Activity 5.5 on pages 183 and 184 of *Visions* 2.

Materials

Data of kinds and number of organisms.

Procedure

- Study the data given in the chart in the Observations section of this investigation.
- Pay attention to the changes in the number of organisms over the eight days.
- Do question 7 on identifying organisms observed in a hay infusion.
- Use the following data to answer the Analysis and Interpretation questions.

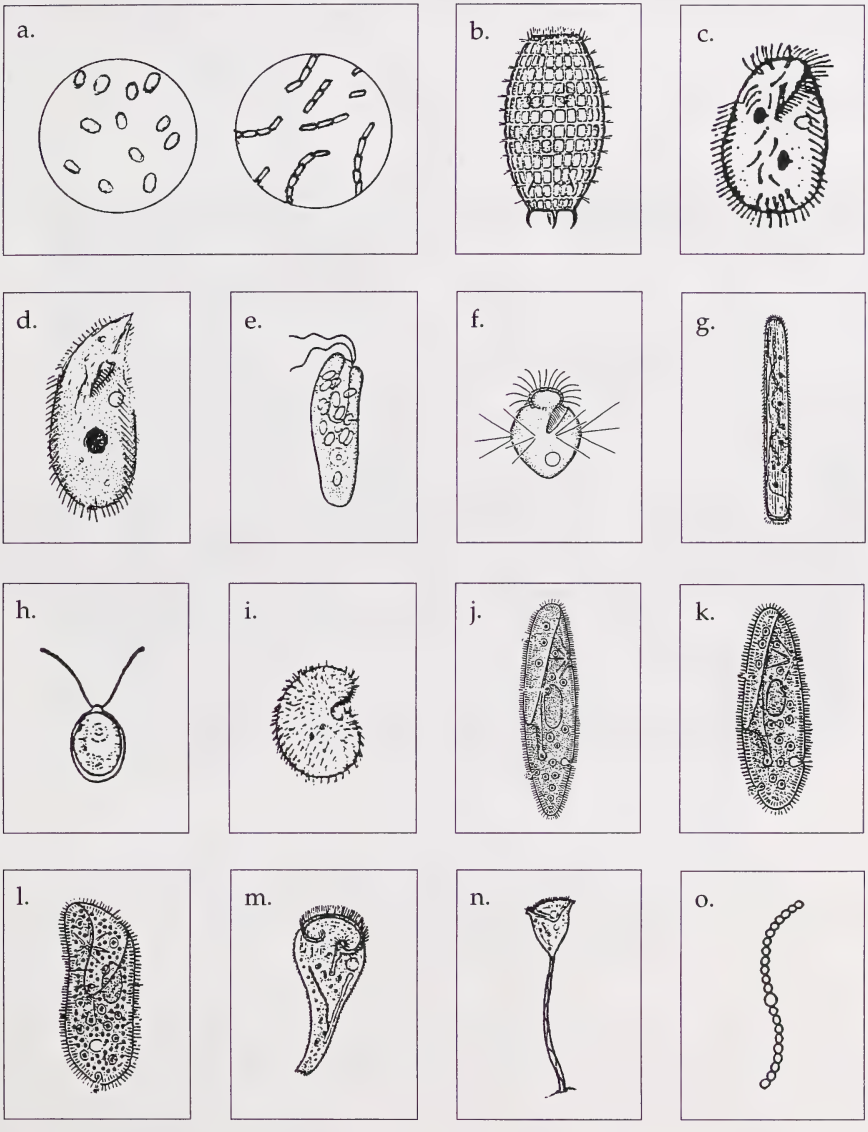
Observations

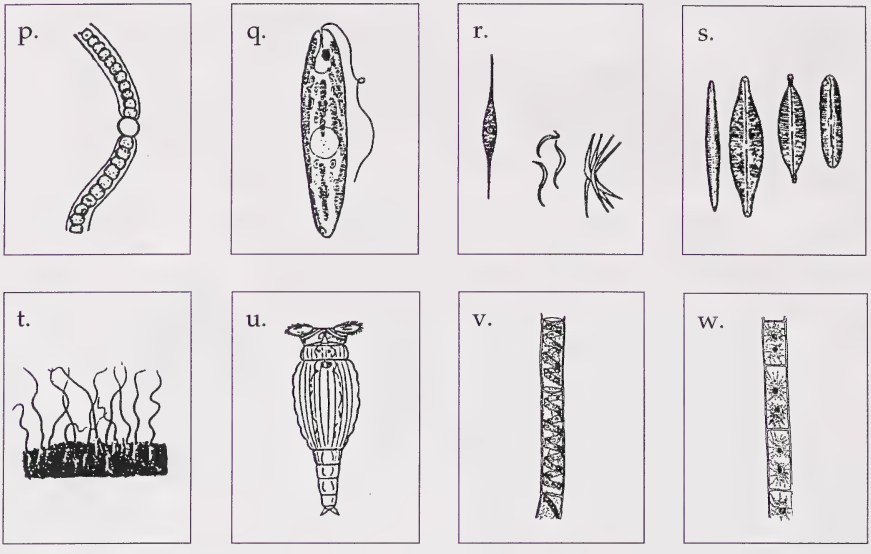
NAME OF ORGANISM	NUMBER OF ORGANISMS EACH DAY							
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Bacteria:								
Aerobic Forms	4.5×10^{3}	9.6×10^{3}	1.6×10^{4}	1.3×10^{4}	1.0×10^{4}	8.4×10^{3}	5.3×10^{3}	1.6×10^{3}
Anaerobic Forms	4.0×10^{2}	8.0×10^{2}	1.6×10^{3}	2.1×10^{3}	4.6×10^{3}	8.2×10^{3}	1.5×10^{4}	2.3×10^{4}
Blue-Green Algae:								
Oscillatoria	28	60	42	18	7	0	0	0
Nostoc	23	57	36	14	4	0	0	0
Green Algae:								
Spirogyra	0	0	4	15	26	19	3	0
Ankistrodesmus	0	0	3	12	21	17	5	0
Zygnema	0	0	5	20	30	22	2	0
Protozoans:								
Halteria	5	25	30	15	5	0	0	0
Chlamydomonas	4	6	12	25	40	35	15	7
Chilomonas	1	3	4	3	0	0	0	0
Vorticella	4	7	11	10	1	0	0	0
Paramecium:								
Aurelia	0	0	1	6	14	12	1	0
Bursaria	0	0	2	4	10	8	2	0
Coudata	0	0	0	2	6	18	5	0
Colpoda	0	1	5	10	25	7	0	0
Oxytricha	0	0	3	9	23	5	0	0
Coleps	0	0	0	7	20	10	1	0
Stentor	0	0	0	0	10	18	0	0
Spirostotem	0	0	0	1	4	12	3	0
Diatoms:								
Navicula	0	0	3	18	38	31	27	5
Rotifers: *Philodina*	0	5	15	37	58	24	7	0
Misc. Invertebrates:								
Nematode Worm	0	0	0	0	0	1	3	1
Sewage Worm	0	0	0	0	0	2	6	10

Legend of Colour
C = clear
B = amber
G = green

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Colour	C	G	G-B	G-B	G-B	G-B	B	B
Temperature (°C)	16	16	17	17	18	18	19	19

7. Identify the organisms observed using the index provided in the Appendix.





Analysis and Interpretation

VISIONS

8. Answer questions 1 to 7 in the Analysis and Interpretation section on page 184 of *Visions 2*.

Check your answers by turning to the Appendix, Section 2: Activity 1.

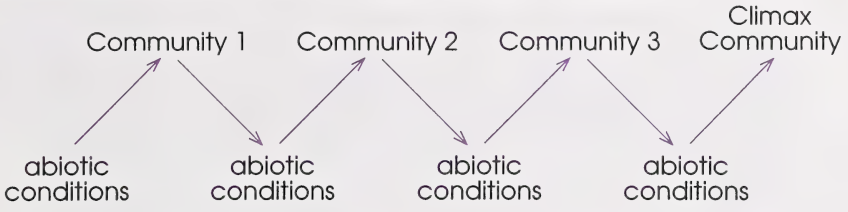
End of Part B

Succession involves both a change in the environment (abiotic factors) as well as the types of organisms living there (biotic factors). Since both are affected, the process of succession must be attributed to the ecosystem and not just the community.

However, a major factor in succession is the impact organisms have on their environment. As the living organisms of the community modify their environment, they may make the new conditions less suitable for themselves but more favourable for another community of plants and animals.

climax community – the final stage in a successional series that is relatively stable, perpetuating abiotic conditions necessary for its own survival

This process continues until a **climax community** becomes established. The following flow chart summarizes the process.



Organisms present at each stage of succession influence the ecosystem in some way. Sometimes the changes are significant like the blue-green algae in the hay infusion investigation. Sometimes the changes are more subtle.

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microclimate – localized climate slightly different from the surrounding area, produced by factors such as topography or vegetation

For example, as shown in the previous photograph larger plants cast shadows that cause minor differences in temperature, wind, moisture, and light in localized areas, producing what is called a **microclimate**. This microclimate will be suitable for some organisms but not for others, so it influences the kinds of organisms that will live there.

Now answer the following questions.

9. Why does succession occur? What causes one community to become well established only to be replaced by another group of organisms later on?

10. Does this process of one community replacing another go on forever? If not, what causes it to stop?

Check your answers by turning to the Appendix, Section 2: Activity 1.

primary succession – the replacement of one community by another until a final stable climax community is established where no life existed before

The kinds of plants present at each stage of succession is essentially controlled by the following two factors:

- environmental conditions
- rate of growth and maturity of the species

The dominant plants in the early stages of succession tend to be smaller, hardy species which grow rapidly and mature quickly. These qualities allow them to become established in suitable environments before other larger plants can take a foothold. Plants of the climax community, on the other hand, tend to grow more slowly and reach a larger size at maturity.

secondary succession – the process of one community succeeding another until a climax community is reached in a region that has been disrupted by factors such as fire, flood, or human activities

Activity 2: Primary and Secondary Succession

You have discovered that not all communities are stable enough to last indefinitely, nor do environmental conditions remain the same. You have also learned that the series of changes in communities leads to a process called ecological succession as the abiotic factors are changed by organisms or by natural causes.

VISIONS

Read pages 185, 186 and 189 of your textbook for background information on **primary succession** and **secondary succession**. Then answer the following questions.

1. In your own words explain the difference between primary succession and secondary succession.

2. What processes contribute to the formation of soil in primary succession?

3. Why are lichens called pioneer plants?

VISIONS

4. What kind of succession occurs in a lake or a pond? What will be the climax community? Refer to the photographs on page 186 of *Visions 2*.

Check your answers by turning to the Appendix, Section 2: Activity 2.

An example of secondary succession is illustrated in the following photo.

ALBERTA FOREST SERVICE

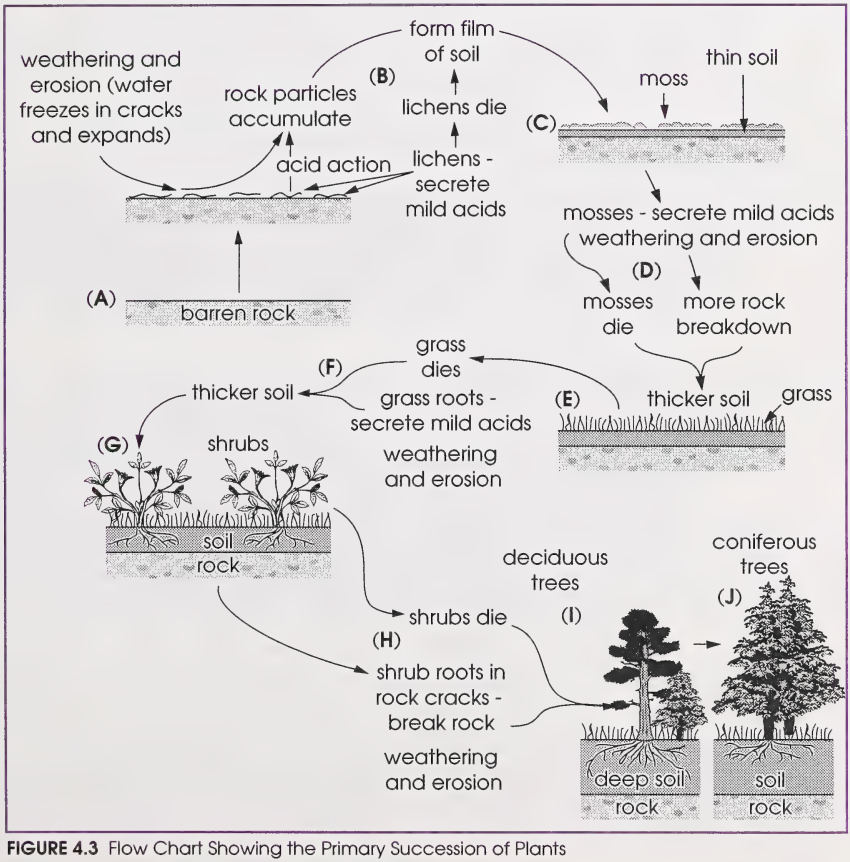


FIGURE 4.3 Flow Chart Showing the Primary Succession of Plants

5. Identify each flow chart or statement as either primary succession, secondary succession, or both. Refer to Figure 4.3.

   a. barren rock (no soil):

      lichens ⟶ mosses ⟶ grasses ⟶ weeds ⟶ shrubs ⟶ climax forest

   b. abandoned pasture (soil present):

      grasses ⟶ weeds ⟶ shrubs ⟶ climax forest

   c. A beaver dam pond is an example of the climax community of this type of succession.

   d. The time span is generally longer in this type of succession.

   e. Pioneer plants contribute to the formation of soil.

   f. The climax community ultimately becomes established.

   g. New deltas, volcanic rock, and other barren surfaces devoid of life are sites of this type of succession.

   h. The dominant species of the climax community has been removed by logging.

Check your answers by turning to the Appendix, Section 2: Activity 2.

DID YOU KNOW?

Canada has three climax communities which are forests. The predominant one is the boreal forest which covers much of northern Alberta. The dominant trees in this community are spruce, pine, and balsam fir.

As the community of plants changes, so do the associated animals. There are few species of organisms in a pioneer community because there are few niches available. Species diversity increases as community succession continues, generally reaching its highest number in the climax community where the greatest number of niches exist. The biomass usually increases as succession progresses up to the climax community. This is especially true of tropical rain forests where the variety of species is especially diverse. In the case of the boreal forest, however, the diversity of species decreases somewhat in the climax state compared to the intermediate stages which consist of mixed forest.

DID YOU KNOW?

Removal of the dominant species of plants (trees) in northern Alberta by logging or clear-cutting results in secondary succession, which takes up to 100 years to produce a new climax community. For this reason, the Alberta Forestry Service tries to speed up the process by planting trees in areas where trees have been cut.

6. Explain why there would be fewer species of animals in a burned-out forest compared to the later stages of succession in the same area.

7. Make and complete a chart similar to the one that follows. Write the word that describes the particular type of community in the appropriate column.

Characteristic	Pioneer Community	Climax Community
number of species (few/many)		
biomass (small/large)		
dominant plant size (small/large)		
number of niches (few/many)		
soil depth (shallow/deep)		
stability (does or does not change abiotic conditions)		

8. Pick a situation in your local area in which a change in the ecosystem occurred in the past year. The change could involve a flood, fire, or road construction. Write a report describing the area, the succession that is occurring, and the end result of this succession. If possible visit the site and make first-hand observations.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment. You may do both.

Extra Help

PATHWAYS

If you have access to the video entitled *Succession: Sand Dunes to Forest* from the *Ecology* series, do Part A. If you do not have access to the video, do Part B. This video may be purchased from Learning Resources Distributing Centre.

Part A

View the video and answer the following questions. You may want to see the video more than once before you begin the questions.

1. Explain how the sand accumulates to form sand dunes.

2. What is drift and how does it contribute to soil formation?

3. Make a chart similar to the one that follows. A representative plant species from each community has been identified for you. In your chart list several animal species that are associated with each one.

Plants	Animals
grass	
cottonwood	
pine	
oak	
beech-maple	

4. How does the sand become fixed in place on the dunes and how is it gradually converted to soil?

5. How do the cottonwoods influence the abiotic conditions below their canopy?

6. What is an index species? Name one index species in the cottonwood community that is a plant and one that is an animal.

7. a. Why is the beech-maple forest considered to be the climax community?

   b. What are the abiotic conditions along the forest floor of the climax community?

8. Explain what is meant by a *blowout*. What will eventually happen in this area over time?

Check your answers by turning to the Appendix, Section 2: Extra Help.

End of Part A

Part B

Ecological succession is the replacement of one community by another as environmental conditions change. It begins in areas where no community existed before as on new rock formed by volcanic activity, or it occurs where an existing community has been disturbed or destroyed as by fire. The replacement of one community by another in succession is primarily due to changes in the environment produced by the organisms themselves. The climax community is one that perpetuates environmental conditions suitable for itself.

9. Match each term listed with the appropriate statement.

• secondary succession	• weathering
• soil	• humus
• climax community	• lichens
• succession	• primary succession
• microclimate	• white spruce

   a. pioneer plants that begin the process of soil formation

   b. the breakdown of rocks by natural elements such as wind, running water, freezing and thawing, and growing roots

   c. the replacement of one community by another until a stable community becomes established

   d. a mixture of sand, silt, clay, and humus

   e. succession that occurs where the dominant species of organisms have been removed

   f. the stable community that maintains relatively constant environmental conditions over time

g. localized environmental conditions produced by larger plants that affect the temperature, humidity, soil moisture, wind, and light

h. one dominant plant in the climax community of northern Alberta

i. the type of succession that occurs where no life existed before such as on newly formed volcanic rock

j. the decomposed remains of plants and animals found in soil

10. Which type of succession (primary or secondary) will occur in each of the following areas?

a. barren rock exposed as a glacier recedes
b. a clear-cut area of forest not replanted with trees
c. an abandoned farmyard
d. a newly emerged island formed by a volcanic eruption
e. an emerging delta formed at the mouth of a large river

Check your answers by turning to the Appendix, Section 2: Extra Help.

End of Part B

11. Describe how each of the following organisms changes its environment.

a. lichens
b. deciduous trees
c. spruce trees

12. Fire is a necessary abiotic component of the ecosystem occupied by lodgepole pines. In what way is it important to the lodgepole pine?

13. Summarize the relationship between energy flow and biomass at each stage of succession in the ecosystem.

14. Explain the following statement: No soil would exist without life and no life would exist without soil.

Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment

Do two of the following four questions.

1. According to the accumulating scientific data, the Earth is warming up as greenhouse gases build up in the atmosphere and trap more heat. Within the next fifty years the climate of Alberta is projected to be warmer and drier than it is today. For each of the following ecosystems that presently exist in Alberta, predict what one of the dominant plants would be if the climate were to become warmer and drier.

   a. grassland in southern Alberta
   b. deciduous forest in central Alberta
   c. coniferous forest in northern Alberta

2. How would dumping raw sewage or wastes containing phosphates into lake water speed up the process of succession in that body of water?

3. The time needed for secondary succession varies from one community to another. A grassland community may take from 20 to 40 years to become reestablished after a disturbance. Tundra, on the other hand, needs hundreds of years. Give two good reasons for the longer period of time required by the tundra.

4. Where tree replanting programs have been employed by pulp and lumber companies, the primary issue has been monoculturing. Should these companies only replant the one particular species of tree they find to have the most commercial value or should they replant all the species of trees that make up the climax community in the region? Discuss.

Check your answers by turning to the Appendix, Section 2: Enrichment.

Conclusion

In this section you have learned that communities continually undergo change. You observed succession in a microenvironment and studied how it occurs in the natural environment. You learned that there are two types of ecological succession: primary succession and secondary succession. The changes occurring through ecological succession result in a climax community where conditions are more stable than in the earlier stages of ecological succession.

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3 Changing Populations

Imagine having the ability to time travel. You have always been intrigued by the past so into the past you go. At first you go back only 100 years and then curiosity drives you back 1000 years. Then you go back 10 000 years, and continue your backward journey until you appear to be the only living thing on the planet. Each time you move backward you visit the same spot on Earth where you presently live. You are shocked to find that Alberta has not always been in the same spot on the globe and has even been submerged under a shallow sea for a time. The plants and animals and the climate have undergone drastic changes many times. One thing becomes very clear during your travels; the biosphere has undergone continuous change since the dawn of time.

WESTFILE INC.

In Sections 1 and 2 of this module you learned that biological communities alter environmental conditions over time and that one community can replace another as environmental conditions change. You learned in Module 1 that the Earth's surface and atmosphere has changed significantly throughout Earth's history, which means that conditions for life also changed. In this section you will develop an understanding of how organisms change as conditions on the Earth change. You will also see that variation of traits occurring in populations are natural and that the environment selects for variations most suitable for survival. You will also discover that population size is affected by change in environmental conditions and that the impact organisms have on their habitat becomes more intense with an increase in numbers.

Activity 1: Variation in Population and Species

FIGURE 4.4 Various Breeds of Dogs

Examine Figure 4.4. These animals are all members of *Canis familiaris*. You probably call them dogs. Are all dogs the same?

1. Make a list of traits that are the same for all dogs; then make a list of traits that are different.

Check your answers by turning to the Appendix, Section 3: Activity 1.

You can see that there are individual differences among members of a species of organism. What causes these differences? Why are they important to a population?

In order to answer these questions, read page 197 of *Visions 2*.

2. What is the source of **heritable variations**?

3. What is a mutation?

4. Sexually reproducing organisms have a built-in source of random variation. Describe this source.

5. Why is genetic variation so important to a population?

ISIONS

eritable ariations – aracteristics at are passed m parents to spring

Check your answers by turning to the Appendix, Section 3: Activity 1.

Now you are ready to apply what you have learned about variations to a population of beetles. Examine the illustration below and answer the questions which follow.

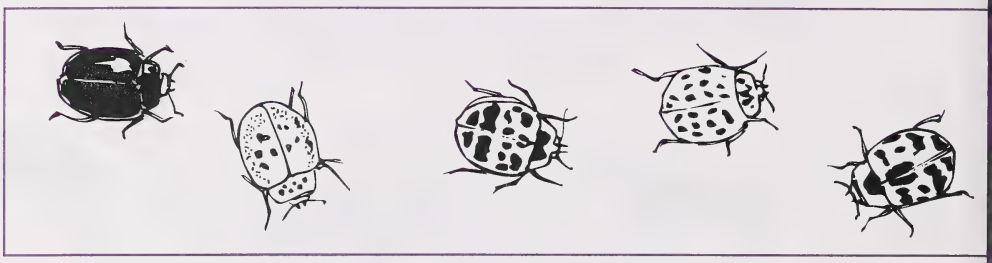


FIGURE 4.5 Colour Variations in Asian Lady Beetles

6. What is one obvious difference between the various individuals of Asian lady beetles shown in Figure 4.5?

7. How do differences in specific traits come about in a population of organisms?

8. What controls the traits of the beetles?

9. How can you explain the variety among the beetles that makes each one different from the others?

Check your answers by turning to the Appendix, Section 3: Activity 1.

Since ancient times people have modified plants and animals over many generations by breeding individuals with desired traits. This practice of artificial selection has resulted in the large variety of dogs, cats, cows, horses, garden plants, flowers, and other familiar plants and animals. If humans can deliberately select certain traits, can nature do this kind of selecting too?

VISIONS

Read Animal Breeder on page 204 of *Visions* 2.

10. What is meant by artificial selection, and how is it useful to humans?

Check your answers by turning to the Appendix, Section 3: Activity 1.

In a natural population, the environment determines which variations in a population are best suited for survival. What characteristics help an organism survive? To explore the answers to this question, do the following investigation.

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☑ F. Evaluating

Investigation: Exploring Factors Affecting Survival

PATHWAYS

If you can work in a group of four, do Part A. If you must work alone, do Part B.

Purpose

In this activity you will investigate some of the factors that affect the survival of birds in their natural habitat.

Part A

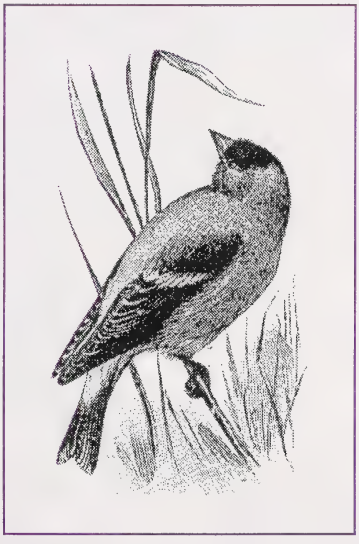
Materials

VISIONS

The materials are as listed on page 201 of *Visions 2*. You may use cardboard disks instead of plastic.

Procedure

- Read the Planning section on page 200 of your textbook; then gather the materials.
- Follow the Procedure on page 201, and make and complete data charts similar to the ones in the Observations section of this investigation.
- Omit the instruction to circle a number in Step 3 of the Procedure in the textbook. Instead, write your number in the chart. The chart is completed by the group; thus, each student represents one bird and should complete one row.
- Modify Step 5 by having each student in the group roll the die four times for each season, and record the sum in the appropriate place in the second chart. Record a survival index for each season.



Observations

11. Record your results in your chart.

Individual Birds	Birth Order	Type of Beak	Resistance to Disease	Feather Type	Adaptation Number
W					
X					
Y					
Z					

Individual Birds	Environmental Conditions Number				Survival Index			
	Spring (4 rolls of die)	Summer (3 rolls of die)	Fall (4 rolls of die)	Winter (3 rolls of die)	Sp.	Su.	F.	W.
W								
X								
Y								
Z								

Note: Sp. – spring; Su. – summer; F. – fall; W. – winter

Analysis and Interpretation

12. a. What combination of characteristics give the birds the best chance of survival?

    b. In this model what is the chance that a bird will survive if it has the following combination of characteristics: brittle beak, low resistance to disease, very poor feather cover, and hatched fourth? (Similar to Bird Y in the sample results in the Appendix.)

VISIONS

13. Answer questions 2 to 9 in the Analysis and Interpretation section on page 202 of your textbook.

Check your answers by turning to the Appendix, Section 3: Activity 1.

End of Part A

Part B

Materials

- 4 small disks (plastic or cardboard)
- grease pencil or felt marking pen
- paper cup
- 1 playing die

Procedure

Step 1: Number the plastic or cardboard disks 1, 2, 3, and 4, and place them in the cup.

Step 2: Make data charts like the ones in the Observations section of Part A. Refer to Table 6.1 on page 201 of *Visions 2*.

Step 3: Without looking, draw a disk from the cup. Record the disk number for the first characteristic, birth order, on the chart for Bird W. Now draw the next number and record that number in the birth order column for Bird X. Do the same for the last two birds. (Do not replace the numbers in the cup each time you draw for one particular trait.)

Step 4: Replace the disks in the cup. Continue drawing disks in this manner until you have numbers for each of the four characteristics for Birds W, X, Y, and Z.

Step 5: For each bird, total the four characteristic numbers to get an adaptation number. The lower the number, the better the chances of survival. Record this number on the chart in the appropriate spot for each bird.

Step 6: To determine spring conditions for Bird W, roll the die four times, and add the four numbers together. Record this number in your chart for Bird W. The higher the number, the more favourable the environmental conditions. Do the same for the other three birds.

Step 7: Now you must determine the Survival Index for the spring by subtracting Bird W's adaptation number from the spring environmental number. If it is negative, Bird W does not survive the spring and you stop rolling the die for Bird W. Calculate the survival index for the other three birds. Only the birds with a positive survival index survive and go on with rolls of the die for the other seasons.

Step 8: Repeat Steps 6 to 7 for the other seasons. Roll the die three times for summer, four times for fall, and three times for winter.

Observations

Complete the charts you made in the Procedure section of this investigation. Refer to question 11 for samples.

Analysis and Interpretation

14. Answer questions 12 and 13 from the Analysis and Interpretation section of Part A.

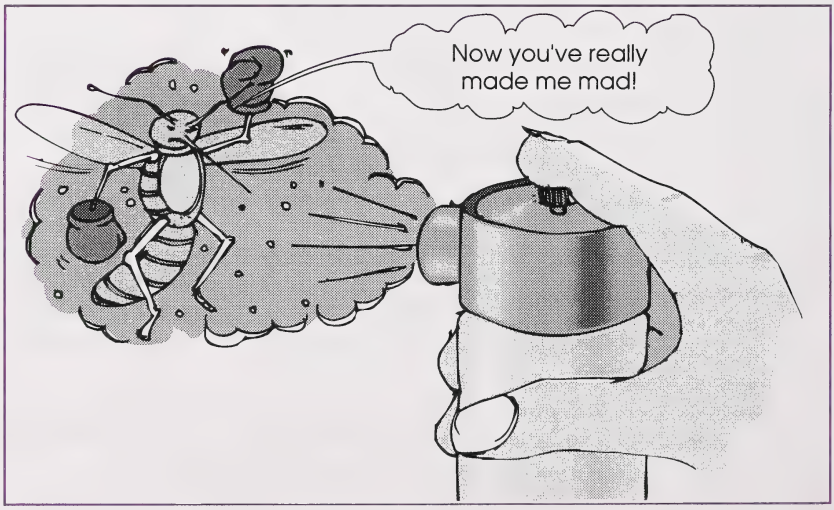
Check your answers by turning to the Appendix, Section 3: Activity 1.

End of Part B

In this activity you have examined some of the conditions and characteristics that help or hinder an organism's chances of survival. In the next activity you will examine a process which increases an organism's chances of survival.

Activity 2: Survival of the Fittest

Imagine you are a scientist sent to an island in the South Pacific to solve a biological mystery. It appears that mosquitoes unpredictably and mysteriously have become resistant to a powerful insecticide called DDT. When DDT was first developed as an insecticide, it was extremely effective in killing a variety of insects including mosquitoes, which transmit malaria. However, after several years of continuous use of DDT, the resident population of mosquitoes became resistant to the chemical. The question you have to answer is how this could happen.



Being a good scientist, you propose two hypotheses. One postulates that the mosquitoes developed a resistance similar to the immunity one acquires to a disease organism after recovering from the disease. The other suggests that in the existing population of mosquitoes there are always a few individuals with resistance to DDT. These mosquitoes are able to survive and reproduce when the population of mosquitoes is exposed to the chemical.

You do your painstaking research looking for the elusive answer. Your research finally presents you with evidence that the latter hypothesis is correct.

Your explanation can be summarized like this. The resistance to DDT occurs naturally and randomly in the population of mosquitoes. When DDT is sprayed, it kills only those individuals sensitive to the insecticide. The resistant ones survive and pass on the genes for their natural DDT resistance to their offspring. Eventually, the overall population of mosquitoes shows DDT resistance.

You announce your results to the island authorities who listen in dismay. What now? How are the mosquitoes to be controlled? Must a new insecticide be developed to replace DDT or must the concentration of DDT be increased in the spray to make it effective again?

VISIONS

To help you give the island authorities the best answer, read Section 6.2 entitled A Consolidating Theory on pages 206 to 210 of your textbook.

1. What is the selective pressure that is operating in the mosquitoes' environment?

2. Where did the resistance to DDT in mosquitoes come from?

3. You should now be able to respond to the question posed by the island authorities. Should they simply increase the concentration of DDT in the spray or do they need to develop a new insecticide to control the mosquitoes?

4. In your own words explain what is meant by *natural selection.*

5. Who first proposed the idea of natural selection?

Check your answers by turning to the Appendix, Section 3: Activity 2.

Environmental conditions select which genes will be passed on to future generations. Traits that are learned are not inherited through genes.

Case Study of the British Land Snail

The British land snail, *Cepaea nemoralis,* lives in patchy environments of wooded areas separated by open fields. There is a range in the brown colour of the shell and the darkness of the stripes. Varieties range from one that is dark brown with distinct black banding through a series of progressively lighter shades of brown and lighter banding. This species of snail is preyed upon by birds which actively seek them out in the vegetation.

All varieties of colour are found in snails of the wooded area and the open fields since the snail is mobile. Interestingly enough, however, there is a predominance of the dark brown, black-banded variety in the shady forested areas and a predominance of the lighter-coloured variety in the brighter open fields.

6. How could you explain the fact that the majority of snails are dark coloured in the forests and light coloured in the open fields?

Even though the environment favours the darker variety in one case and the lighter variety in the other, the result of this whole situation is that both colouration patterns are suitable depending on where the snail finds itself. Thus, no net change in colour will evolve.

7. If the snails were to stop migrating back and forth between the dark wooded areas and the open fields, how would the colour of each population change over time? Explain.

Check your answers by turning to the Appendix, Section 3: Activity 2.

The reproductive potential of most species, including the slowest-breeding ones, is incredibly high. This continuous addition of new individuals to the population leads to a struggle for existence among the members that increases with rising numbers. Consider the reproductive rate of one pair of houseflies (*Musca domestica*) over the course of one year. Assume that each female produces 120 offspring per generation and that all individuals survive.

TABLE 4.1 THE REPRODUCTIVE POTENTIAL OF THE HOUSEFLY

Generation	Numbers if All Survive
1	120
2	7 200
3	432 000
4	25 920 000
5	1 555 200 000
6	93 312 000 000
7	5 598 720 000 000

If the flies were to continue reproducing at this rate, it wouldn't take long before they took over the entire Earth.

8. What assumption made in this scenario is incorrect in the real situation? Explain.

Many species of organisms produce large numbers of offspring to ensure the continuation of the species. Think of all the seeds produced by one dandelion flower. Very few of these, however, actually reach maturity and reproduce. Vertebrates generally produce fewer offspring than do invertebrates, but a greater percentage of vertebrate offspring survive to maturity.

9. Darwin suggested that there is a struggle for existence that occurs among individuals of a species preventing all the offspring from surviving and leading to survival of the fittest. What do you think he meant by this statement?

VISIONS

10. How does the struggle for existence change for individual houseflies as the population increases? Explain.

Read pages 202, 203, and 205 of your textbook to learn more about **adaptation**, **fitness**, and **natural selection**. Then answer the next question.

adaptation – an inherited trait that enhances an organism's chance of surviving and producing offspring

fitness – the reproductive success of an organism

natural selection – a process whereby individuals possessing certain variations are able to survive more successfully, produce more offspring, and thus increase the frequency of these favourable variations in subsequent generations

11. The long neck of the giraffe is considered to be an adaptation. Explain how the neck of the giraffe evolved to its present length, using your understanding of mutation and Darwin's concept of natural selection.

Review your reading from pages 206 to 210 of the textbook that relates to the peppered moth, *Biston betularia*, in England.

In the population of these moths, there are the black and the white varieties. During the early 1800s the black form was a rare find in both rural and urban regions. Around the middle of the century the black variety became much more common, particularly in the industrial areas of the country.

12. Explain how and why the fitness of the peppered moths changed during the nineteenth century.

Check your answers by turning to the Appendix, Section 3: Activity 2.

In this activity you learned about a process which allows the best-suited organisms of a particular species to survive. In the next activity you will learn how paleontologists trace an organism's ancestors.

Activity 3: Evidence for Similar Ancestors

If you were to walk along the banks of the Red Deer River near Drumheller, Alberta you might scan the rock faces and even casually turn over the occasional flat piece of shale. You might discover a number of imprints of ferns and leaves on some of the rocks and fossilized snails, bones, and teeth on others. Your eye may catch a glimpse of a much larger, fossilized bone partially protruding from a layer of rock. Later when this bone is extracted by paleontologists, you may be informed that you have found the remains of a member of the condylarths group, which gave rise to several groups of mammals including the horse, the camel, and the elephant.

How do paleontologists determine these ancestral lines? If one ancient group gives rise to several modern groups of organisms, does this mean that there are more species today than there were in the past? Suddenly you have a number of questions that need answering. If possible, a visit to the Royal Tyrrell Museum in Drumheller, Alberta would provide a wealth of information on this topic. If you have already visited the museum, try to recall what you saw as you complete this activity.

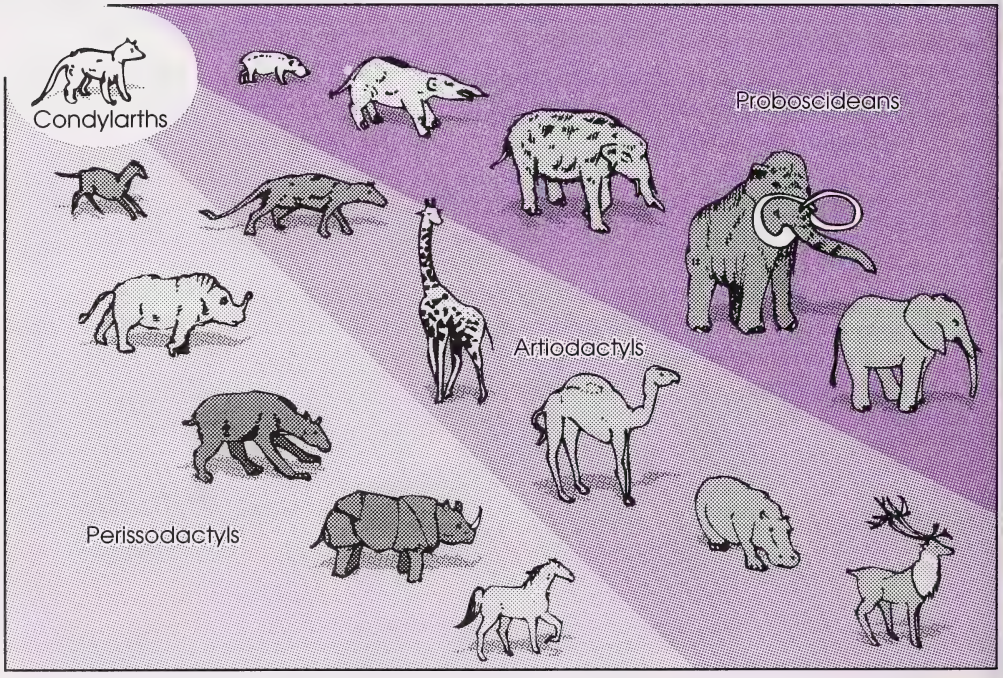


FIGURE 4.6 Descendent Branches of the Condylarths Group

The fossil record strongly suggests that the number of species living on Earth today far exceeds the number that existed on this planet millions of years ago. It appears that as you go back further and further in time, diversity of organisms decreases. Modern organisms that are similar seem to have evolved from a common ancestral line according to the fossil evidence. Taking this to the extreme, it can be speculated that all life-forms may have originated from one common ancestral form some 3.5 to 4 billion years ago. Whether this is the case or not is a question that will be difficult to answer.

VISIONS

Read pages 210 to 213 of *Visions 2* to find out what paleontologists have learned about past life-forms and to gain a better understanding of the process of **speciation**.

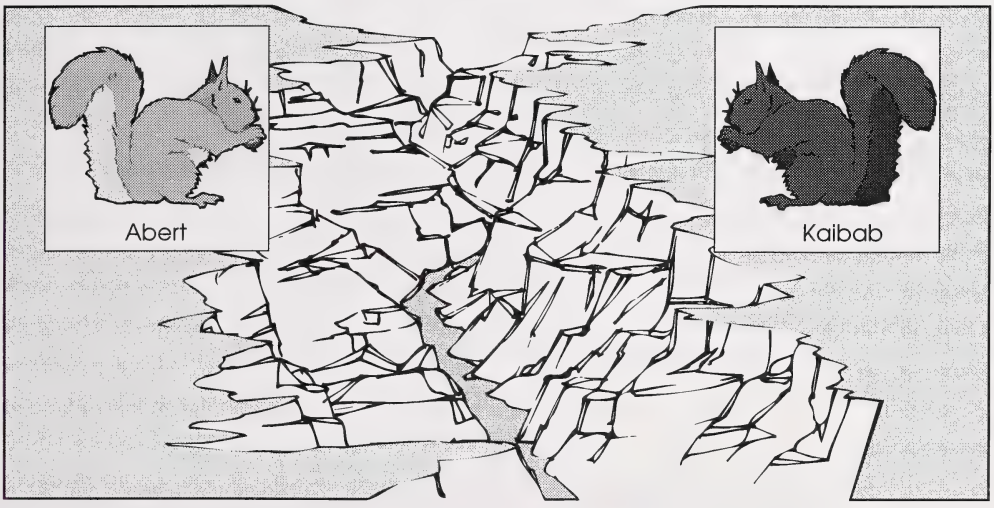
speciation – the formation of one or more new species through genetic isolation

1. Using the fish shown in Figure 6.6 on page 212 of *Visions 2* as an example, describe how two **species** may result from one population of organisms.

species – a group of organisms that live together, share common traits, and interbreed under natural conditions

2. Explain what is meant by selection pressure. What role does it play in speciation?

3. The Abert and Kaibab squirrels live on opposite sides of the Grand Canyon. It is believed that they were once one population of squirrels, but over millions of years they became quite different in appearance and now they cannot interbreed even when brought together. See P-15, plate 6.2 of *Visions 2*.



geographical isolation – the physical separation of a population into two or more groups so that the groups cannot interbreed; results in genetic isolation

   a. What caused the **geographical isolation** of the squirrel population?

   b. Why did the two populations become different?

   c. Can these two types of squirrels be considered separate species? Explain.

4. Speciation requires reproductive isolation. Explain what this is and how it could occur.

Darwin was the first to present evidence for geographic and reproductive isolation which leads to divergent evolution. He pointed out that there was a close resemblance between plants and animals on oceanic islands and those of the nearest continent. This seemed to indicate that the island forms evolved from individuals that came to the islands from the adjacent mainland at some point in the past. One classical example of the evolution of such differences is the case of the Galapogos finches. There are fourteen species of these finches, all quite similar in size and shape. It is very likely that they all originated from a few South American finches that accidentally arrived on these islands at some point in the past. Use Figure 4.7 to answer the next two questions.

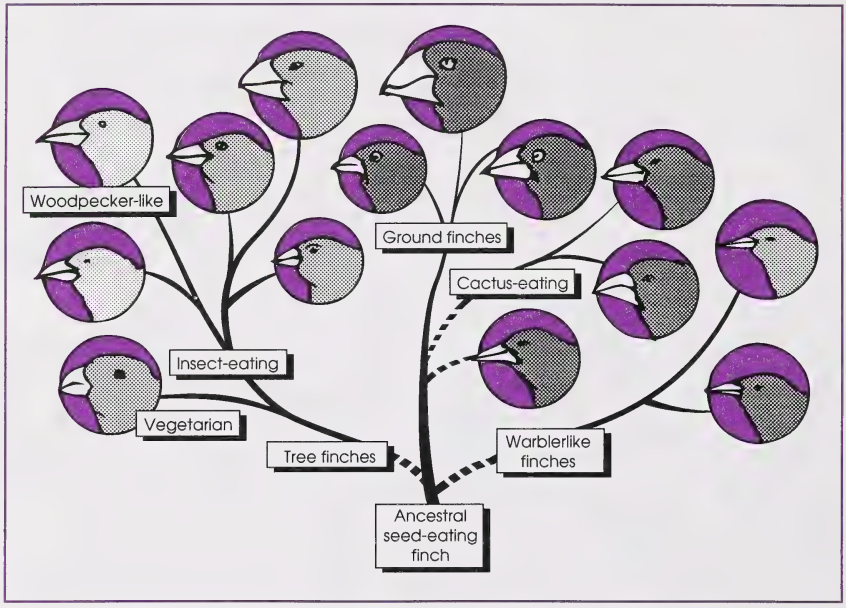


FIGURE 4.7 Evolutionary Variation in Galapogos Finches

divergent evolution – the evolution of two or more species from one ancestral species whose population became fragmented and genetically isolated such that different selective pressures affected each group

5. a. What two traits vary among the different species?

   b. How could these differences be explained if all the finches arose from the same ancestors?

Check your answers by turning to the Appendix, Section 3: Activity 3.

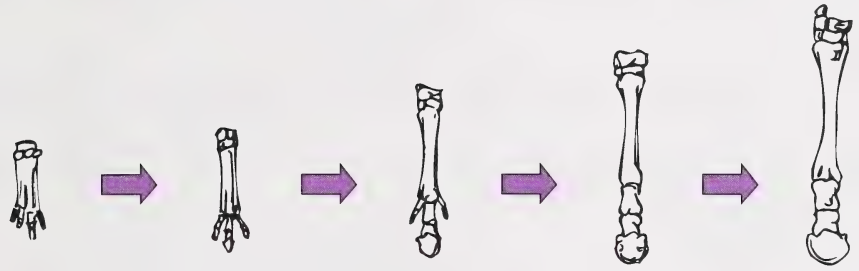
VISIONS

Recall your study of fossil records in Module 2 of this course. Fossil records show that not only did diversity of organisms increase over the course of the Earth's biological history but so did the complexity. This would suggest that **divergent evolution** has played a significant role in producing the variety of organisms you see in the biosphere today. To see a representation of the increasing diversity of organisms over Earth's history, see P-3, plate 2.1 of *Visions* 2.

DID YOU KNOW?

Radioactive dating and other forms of evidence indicate that the Earth is about 4.5 billion years old. Radioactive dating has a margin of error of plus or minus 10%.

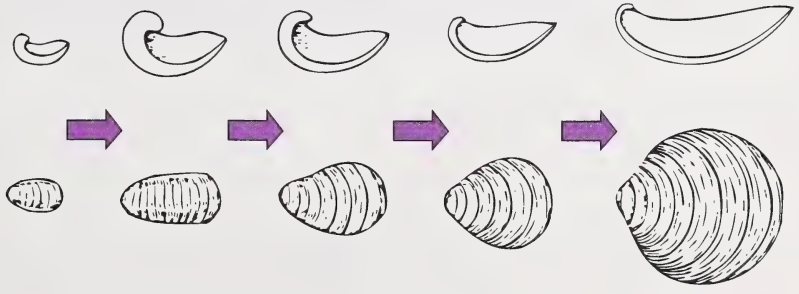
There are many examples of organisms changing in some way from past to present. Study the figures of the horse's foot as it underwent evolutionary change over a period of 50 million years.



6. How did the number of toes change from the earliest form of the horse to the present form?

Check your answers by turning to the Appendix, Section 3: Activity 3.

About 200 million years ago the shells of oysters underwent a gradual change from small, curved shells to larger, flatter ones. This progressive change can be seen in the fossil records over a period of 12 million years.



Many other examples of evolutionary change are known from the fossil records. You may want to read about them in other references that can be found at the nearest library.

Although populations of organisms gradually change through time, the rate at which each species undergoes change varies greatly. The horse has undergone a relatively rapid change over the last 50 million years, whereas the horseshoe crab shows little difference in structure and is much like its ancestor of 160 million years ago.

Evidence for evolution comes from findings in paleontology, embryology, and biochemistry. One major line of evidence comes from the study of comparative anatomy, in which structures of modern species are compared.

VISIONS

Read the section titled Variations and Similarities Exist Between Species on pages 213 and 214 of *Visions 2*.

Investigation: Inferring Significance of Structural Adaptations

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

If members of a group such as the mammals originated from a common ancestor, they should show **homologous structures**.

homologous structures – structures of similar origin that serve different functions

Purpose

In this investigation you will look at the bone structure of the forelimb of several vertebrates to see their similarities and how they have been modified to serve a specific purpose. You will also compare these to the forelimb of an ancestral vertebrate.

Materials

The materials are listed in Activity 6.2 on page 215 of your textbook. Use any encyclopedia, animal reference book, or biology text you may find in a library or at home that provides the required description.

Procedure

VISIONS

Follow the steps outlined on page 215 of *Visions 2*. If you have to work alone on this activity, then do all parts as described and ignore the reference to groups.

Analysis and Interpretation

7. Answer questions 1, 2, and 3 found on pages 215 and 216 of your text.

analogous structures – structures that have a similar function but are quite different in internal structure and evolutionary origin

You have just looked at structures that are similar in origin and structure but have different functions. These structures are called homologous structures. In your reading on page 214 of *Visions 2*, you also came across the term **analogous structures**.

8. Look carefully at the various structures in Figure 4.8. Which ones would you consider to be analogous structures?

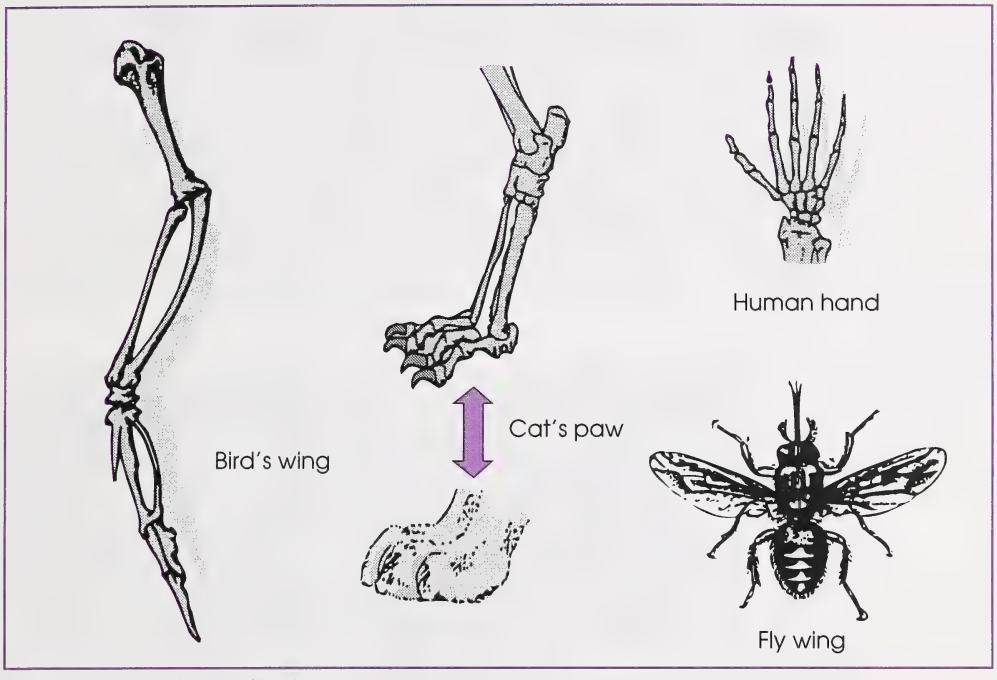


FIGURE 4.8 Various Skeletal Structures

9. How do analogous structures compare with homologous structures?

10. Explain why homologous structures are thought to follow a divergent process and analogous structures are thought to follow a convergent process.

Check your answers by turning to the Appendix, Section 3: Activity 3.

To reinforce some of the concepts in Activities 2 and 3 you may wish to view the video entitled *Organic Evolution: Darwin, Naturally*. This video is available from ACCESS Network.

In this activity you learned about the processes involved in survival and how changes in structures allow some organisms to survive better than others. In the next activity you will look at how the size of populations is maintained.

Activity 4: Maintaining a Balance

If you were hiking in the area around Swan Hills, Alberta and came upon a grizzly bear close enough to be seen clearly, you would be able to describe it in general terms: massive body, brownish hair except for silver-tipped hair on the shoulders, huge paws and head, small beady eyes, and short ears. On the other hand, if you were a biologist studying these animals, you would notice individual differences. Although grizzly bears in the Swan Hills area differ from each other because of genetic variability, the fact that they interbreed means that they share a common **gene pool** and belong to the same species.

gene pool – the total of all the different kinds of genes in a population

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As long as the environment remains suitable, the population of grizzly bears will continue to persist even though individuals are born and die and members immigrate and emigrate. Over time, then, the actual individuals that make up the population change. The number of individuals also changes, resulting in fluctuations that can be quite regular.

VISIONS

Read pages 216 to 219 in *Visions 2* carefully for more details on population characteristics.

1. Define the following terms:

   a. natality
   b. mortality
   c. immigration
   d. emigration

2. What processes in question 1 increase population size and which ones decrease it?

3. Identify each of the following as an **open population** or a **closed population**.

   a. three pet gerbils in a cage
   b. the whitetail deer population in Alberta
   c. the elk population in Elk Island National Park
   d. the coyote population in the city of Edmonton

open population – a natural population which varies in size over time because individuals not only are born and die but are also free to immigrate or emigrate

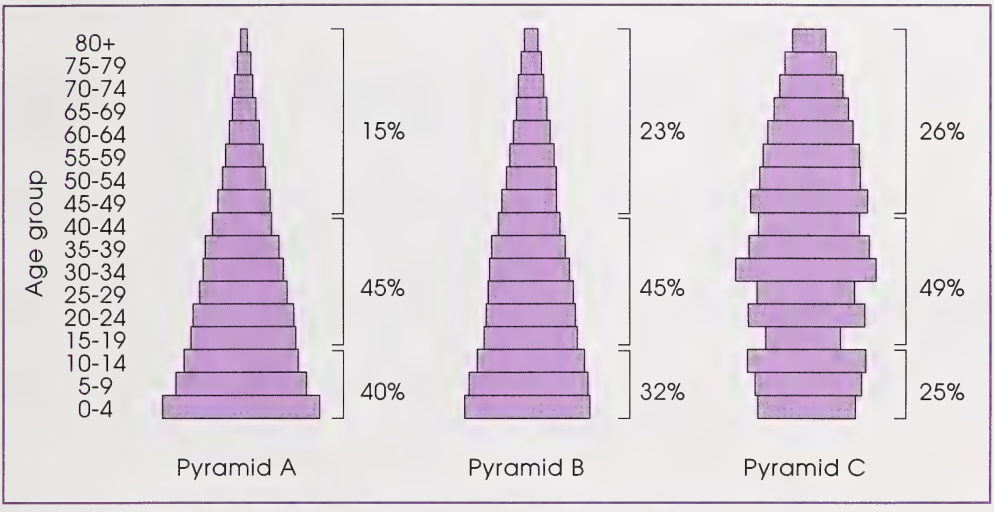
closed population – a population with artificial boundaries which restrict organism movement in or out such that size is influenced only by birth and death

In order to predict trends in population growth, two factors must be considered: **fertility** and **survivorship**.

fertility – potential for producing offspring

survivorship – a measure of how many organisms in a population reach a certain age

4. Study the three age pyramids for humans. Indicate, in each case, whether the population represented is increasing, decreasing, or stable.



Check your answers by turning to the Appendix, Section 3: Activity 4.

Science Skills

- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☐ F. Evaluating

Investigation: Studying Population Growth

Enough studies have been done to show that there are typical growth patterns and predictable size limitations to populations given certain environmental conditions. In this investigation you will study a population growth pattern that begins with ideal conditions and then becomes less suitable with time.

PATHWAYS

If you have access to laboratory facilities, do Part A. If you do not have access to laboratory facilities, do Part B.

Part A

Purpose

In this investigation you will discover the pattern of population growth and the limiting factors controlling population size.

Materials

VISIONS

The required materials and equipment are listed on page 219 of *Visions* 2.

Procedure

Follow the steps in the Procedure section outlined on pages 219 to 221 of your textbook for Day 0 and for Days 1 to 10.

Observations

5. Record all your counts in a chart like the one shown on page 220 of *Visions* 2.

6. Plot a graph as described in Step 2 of Observations section on page 221 of *Visions* 2.

Analysis and Interpretation

7. Answer questions 1 to 5 on page 222 of your textbook.

Check your answers by turning to the Appendix, Section 3: Activity 4.

End of Part A

Part B

A Science 20 student performs the investigation on yeast population growth and obtains the data provided which follows the procedure. Use these observations to complete Part B.

Purpose

You will see the characteristic growth pattern of a yeast population and identify the factors that limit growth in a closed population.

Materials

A data sheet of observed yeast growth is provided.

Procedure

Figure 4.9 represents population samples taken from a test-tube yeast population. The samples are on special glass slides with lines etched on them for easier counting. Each figure represents the view as seen through a microscope.

Step 1: Count the total number of yeast cells in each of the three samples for 0 h. To avoid double counts, place a dot inside those cells counted as you go along.

Step 2: Make a data chart like the one found in the Observations section. Record in your data chart the number of cells counted in each of the three areas for 0 h of growth.

Step 3: Add the three counts to get a total number of cells for 0 h and record this number in the appropriate column in your data chart.

Step 4: Compute the average number of cells per area. Record the average in your chart.

Step 5: Repeat the four previous steps for yeast samples at 24 h, 48 h, 72 h, 96 h, and 120 h.

Step 6: Since the volume of the fluid placed on the slide was about $\frac{1}{1000}$ of the total fluid of the yeast culture, the counts you have recorded must be multiplied by 1000 to give the actual populations at each time. Record the total number of yeast cells in the column of your data chart labelled Entire Population.

Step 7: Construct a graph of your data on graph paper with time on the horizontal axis and number of yeast cells on the vertical axis. Plot time in 24-hour intervals and number of cells in intervals of ten thousand.

Observations

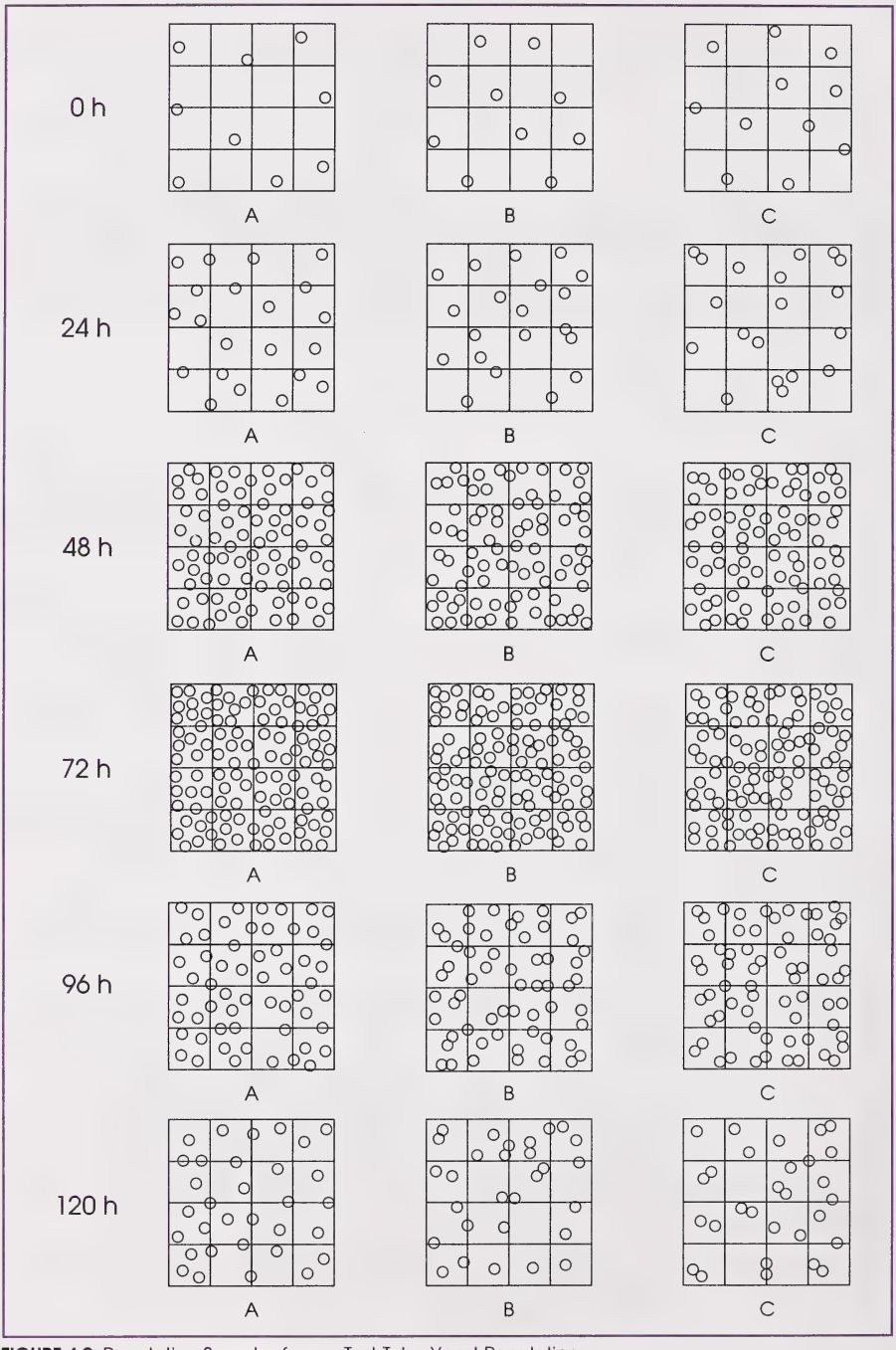


FIGURE 4.9 Population Samples from a Test-Tube Yeast Population

8. Record the results in your chart.

Hours	Area A	Area B	Area C	Total	Average	Entire Population
0						
24						
48						
72						
96						
120						

9. Construct a graph of your data as described in Step 7 of the Procedure.

Analysis and Interpretation

10. During which time interval is growth the slowest? When is growth the fastest?

11. Explain why the initial growth is geometric or exponential.

12. After reaching a peak, the yeast population began to decline. What biotic and abiotic factors may have caused this?

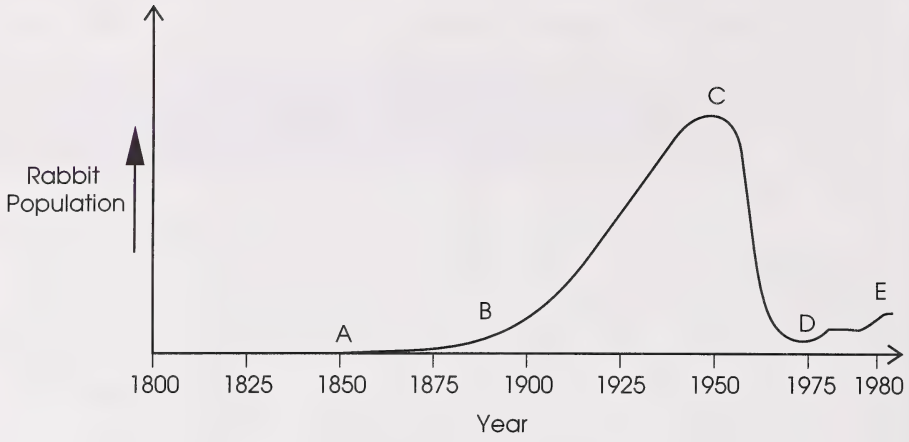
Check your answers by turning to the Appendix, Section 3: Activity 4.

End of Part B

VISIONS

You have seen from the investigation that when conditions are ideal, an organism like the yeast will undergo a rapid increase in numbers. The more individuals there are, the faster the growth rate of the population, resulting in what is commonly known as exponential growth. When such growth is graphed, you will get a characteristic J-shaped curve rather than a straight line. See Figure 6.10 on page 222 of *Visions* 2.

Study the following graph of the rabbit population in Australia from 1825 to 1980 and answer question 13.



13. a. Approximately when was the rabbit introduced to Australia?

    b. What part of the graph shows exponential growth?

    c. What was the specific cause of the dramatic drop in the population in 1950? If you cannot remember the answer, go back to Section 1 of this module and read the case study on the Australian rabbit given in Activity 5: Exotic Species – Community Intruders.

    d. What trait did the rabbits acquire after 1960?

biotic potential – the maximum rate of reproduction under ideal conditions

VISIONS

You should gain a much better understanding of what factors influence populations and how populations respond to these factors by reading pages 222 and 223 of your textbook.

14. What three factors affect **biotic potential**?

carrying capacity – the population an ecosystem can indefinitely support

15. Study the graph of the snowshoe hare given on page 224 of *Visions 2;* then answer the following questions.

    a. The dotted line represents the **carrying capacity** of the environment. Explain what that means.

    b. Fluctuations in the population above and below the carrying capacity of the environment is a natural feature of open populations. Give the biotic and abiotic factors that cause the fluctuations in the population once it levels off near the carrying capacity. Explain how these factors affect the population.

VISIONS

Read page 224 of *Visions 2* about how different species survive by having different population growth rates over time. Answer questions 15 to 17 based on the following scenario.

Whitetail deer live in stable habitats of grassland mixed with stands of aspen forest which provide cover for the deer during the day when they rest. The females generally produce one or two fawns in the spring of each year, nurturing and protecting them until they are large enough to survive on their own. Adults generally live five to ten years and the average buck reaches his peak of virility at about five to seven years of age. One insect pest the deer must endure in the summer is the mosquito, which appears in small numbers early in the summer but quickly undergoes a population explosion under suitably moist conditions. Hordes of these ectoparasites will follow the deer around in their quest for a meal of blood. Adult mosquitoes only live a few days, just long enough to reproduce. The number of these insects swings violently during the summer depending on the wetness since the larvae develop in puddles of water. The mosquito quickly disappears in the fall with the first few heavy frosts which kill the larvae.

16. Which organism described is the K-selected species and which is the r-selected species?

17. Identify the general features of each category.

18. Draw the survivorship curve for each type of species.

Check your answers by turning to the Appendix, Section 3: Activity 4.

In this activity you have studied the factors which keep a population in check. You have learned that the populations of some organisms such as flies fluctuate greatly over time while the populations of other organisms such as deer are quite stable. In the next activity you will study the growth of the human population as well as some of the consequences of this growth on the environment.

Activity 5: Human Population Growth

Fossil records show that populations of humans (*Homo sapiens*) were abundant in Europe and Asia between 70 000 and 32 000 years ago. They spread across Siberia and reached the New World after the Ice Age some 12 000 to 13 000 years ago. By the end of the Pleistocene Epoch, about 10 000 years ago, there were only about 10 million people throughout the entire world. Evidence shows that even then people had a great impact on other organisms, apparently being responsible for the extinction of many populations of animals and plants. Now the human population stands at an incredible 5 billion and continues to grow at a phenomenal rate of 93 million individuals per year. The human impact on the environment today is a very serious concern.

Science Skills

- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☑ F. Evaluating

Investigation: Human Population Growth

Purpose

In this investigation you will simulate the growth of the human population by studying the growth of money which has been wisely invested. You will then consider where the human population may be headed in your lifetime.

Materials

- graph sheet
- pencil
- ruler

Procedure

- Assume that you start with one dollar. By cleverly investing it, you double your money each day for twenty days.
- Make a data chart similar to the one found in the Observations section. Record the amount of money you would have at the end of each day in your data chart.
- Plot your data on a graph. Place the number of days along the horizontal axis and the amount of money along the vertical axis.

Observations

1. Record your results in your chart.

Day	Amount ($)	Day	Amount ($)
1		11	
2		12	
3		13	
4		14	
5		15	
6		16	
7		17	
8		18	
9		19	
10		20	

2. Draw a graph of your results.

Analysis and Interpretation

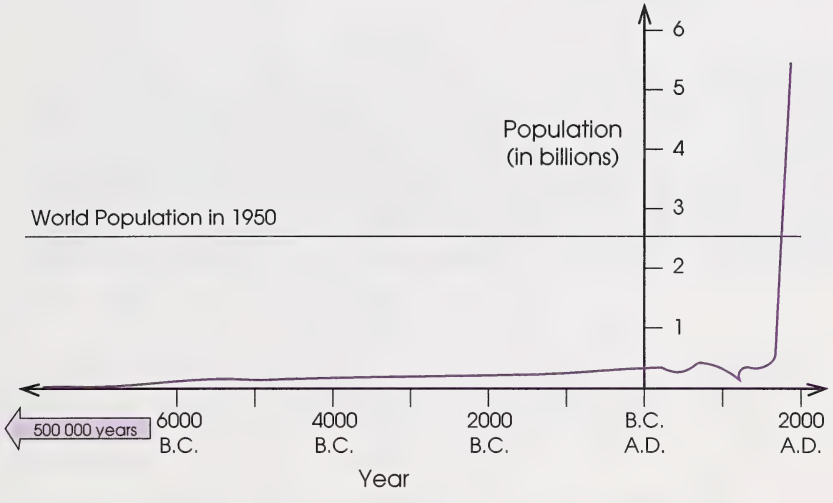
3. By what proportion does the money increase each day?

4. Do you seem to make most of your money during the first fifteen days or the last five days?

5. When do you become a millionaire?

Compare your graph of money growth to the graph of human population growth that follows. Then answer questions 6 to 9.

Human Population Growth



6. How are the two graphs similar?

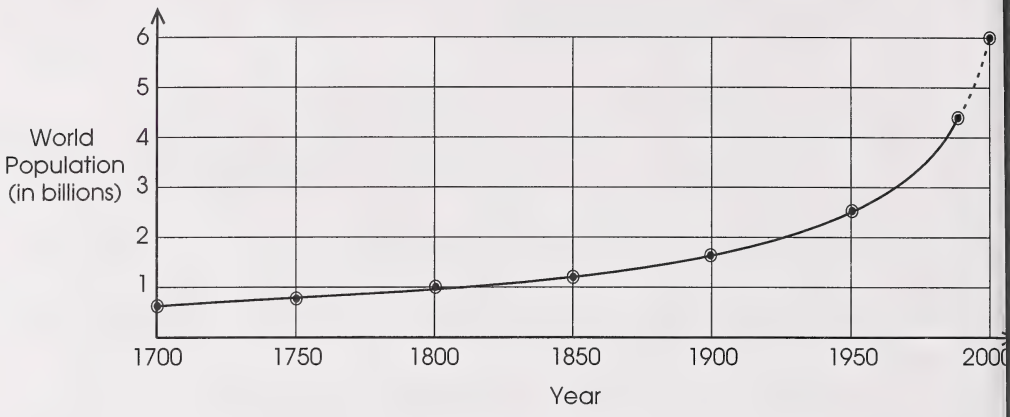
7. Unlike the growth in money, what must ultimately happen to the growth of the human population?

8. Give some reasons why the human population remained relatively low up until the 1800s.

9. What is the cause of the dip in the line in the fourteenth century?

10. Predict the carrying capacity of the Earth for the human population.

Use this graph to answer question 11.



11. It took approximately 12 000 years for the population of modern humans to reach the first billion.

    a. How long did it take to go from 1 to 2 billion? How long did it take to increase from 2 to 3 billion?

    b. What is the trend in the amount of time needed to increase the human population by 1 billion?

    c. What biotic or abiotic factor will likely be the major limiting factor to cause the human population to stabilize?

    d. Once stabilized, do you think the human population will undergo the typical cyclic fluctuations in numbers seen in other open populations such as the hare? Explain.

Like all other organisms on this planet, humans are a product of the environment and the result of evolutionary processes. Though *Homo sapiens* is an integral part of nature, the species is different from all others in its ability to change the environment to suit its needs.

12. Give some ways in which humans alter their environment in order to support the present population.

Check your answers by turning to the Appendix, Section 3: Activity 5.

The exponential growth of the human population has had a major impact on the environment, and it has produced some challenging problems during this century. Humans have damaged or completely eliminated some natural ecosystems by converting them for other uses. This threatens the survival of particular species and even whole ecosystems.

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VISIONS

The air and water has been polluted in many parts of the world, endangering the health and vitality of all life in those areas. In a short 100 years, the total human impact on the environment has reached crisis proportions. To avert a crisis the world must look at sustainable development. Read Sustainable Development on pages 227 and 228 of your textbook, and answer the questions which follow.

13. Do questions 1 and 2 on page 228 of *Visions 2*.

14. a. The world is as finite for humans as the jar was for the yeast cells. Considering what ultimately happened to the yeast population, what may be the end result for humans and other life-forms if the human population continues to grow and humans do not alter their effect on the environment? What would likely be the main cause of this?

    b. Suggest some possible solutions to the negative human impact on the environment, taking into account what you can do personally.

Check your answers by turning to the Appendix, Section 3: Activity 5.

In this section you have seen that the traits of organisms change as environmental conditions change. The organisms best suited to the environment survive and over time the organisms with these particular traits become the predominant population. Populations rise and fall as organisms have an impact on their environment, changing the environment which in turn has an impact on the organisms. The human population is one that has learned to change its environment so that it is not as readily affected by natural fluctuations. The question is whether this can continue indefinitely.

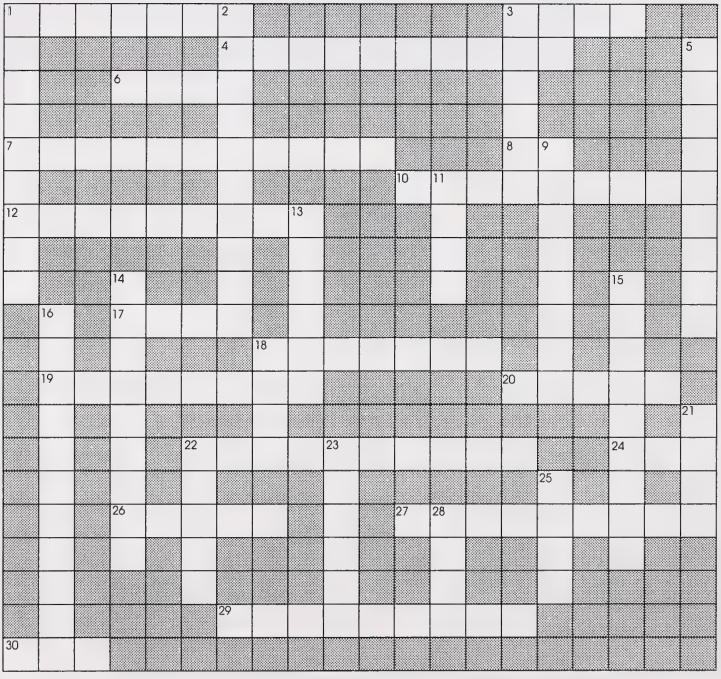
Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a good understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

The study of biology requires that many new terms be learned. Review some of the terms introduced in this section by completing the following crossword puzzle.

1. Complete the following crossword puzzle.



Across

1. a group of similar organisms that live together and interbreed under natural conditions, producing fertile offspring
3. to locate fossilized remains
4. individuals of the same species that exist in a specific area at a particular time
6. time of existence of a living thing
7. interaction among organisms in their quest for the same food and other similar needs
8. opposite of out
10. the state of being separated from another group either physically or genetically
12. traits received from parents through transfer of genetic material
17. a type of population in which individuals are free to enter or leave
18. survival success of an organism
19. sudden change in the structure of the genetic material, DNA
20. to go around in repetitive fashion
22. structures of similar origin but different function
24. black oily remains of ancient organisms
26. characteristic or feature of an organism
27. structures similar in function but not in evolutionary origin
29. evolution that gives rise to two or more species from an original one
30. the abbreviation for the chemical that makes up genes

Down

1. the act of picking or choosing
2. the formation of new species through isolation and natural selection
3. petrified remains of an organism
5. the number of offspring produced by a female over a given time
9. birth rate
11. magnitude of a population
13. scientist who first proposed the theory of natural selection
14. death rate
15. process by which changes occur in the genetic makeup of a population
16. the movement of individuals into a region
18. the general shape of something
21. periods of time in Earth's history
22. excessive weight as that in many dinosaurs
23. small
25. the genus name for the human species
28. the common or scientific reference to a specific organism

Check your answers by turning to the Appendix, Section 3: Activity 5.

PATHWAYS

If you have access to the video entitled *Aspects of Ecology: Populations*, do Part A. If you do not have access to the video, do Part B. This video is available from ACCESS Network.

Part A

View the video and answer the following questions.

2. List the things that members of a single population have in common.

3. Write a definition of a population.

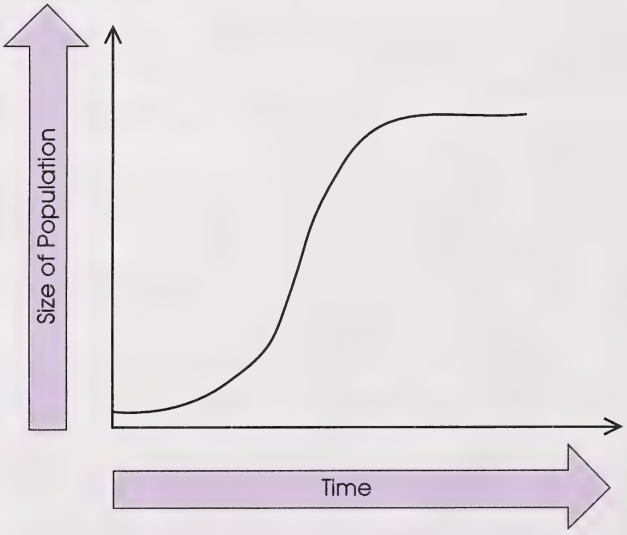
4. What environmental factors limit the number of individuals comprising a population?

5. There are two terms used to describe the patterns of dispersal of population members. Name and describe them.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

6. The bison population of Elk Island National Park is now at the environment's carrying capacity. Make a graph like the following; then draw a dotted horizontal line to show the carrying capacity.



7. What factors other than the ones mentioned in question 3 control the bison (or any other) population?

8. Give three examples of how humans have intervened to benefit populations.

9. What did Thomas Malthus say about the human population?

10. The present human population, of around four billion, may double to eight billion in as little as thirty years. What three factors may eventually limit this growth?

Check your answers by turning to the Appendix, Section 3: Activity 5.

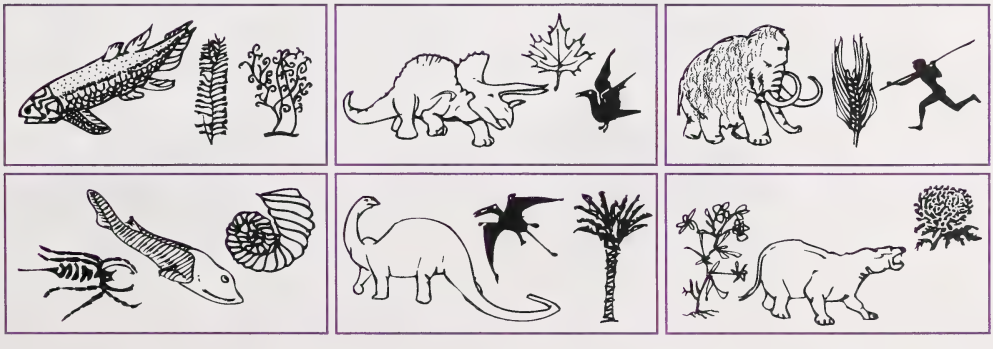
End of Part A

Part B

Read the following summary of this section and answer the questions that are given to improve your understanding of the major concepts.

Radioactive dating indicates that the Earth is about 4.5 billion years old. Geological evidence clearly shows that conditions on this planet since the beginning of time have not remained constant, nor have the organisms that appeared here some 2.5 billion years ago. There has been a gradual increase in variety and complexity of organisms over time, somewhat similar to the increase in variety and complexity of cars and other technology since the beginning of the industrial revolution.

The increase in variety can be explained genetically. Variations among living organisms are the result of differences in genetic information encoded in the DNA. Changes in the structure of DNA that lead to changes in specific traits of the organism are the result of mutations. As these mutations or changes in the DNA accumulate in populations over time, variations in traits also increase as a result. Since there is constant competition among members of a species which leads to a struggle for existence, some of these variations give the individuals possessing them a competitive advantage over other individuals. These individuals are deemed better fit in that they are more likely to live long enough to produce offspring and to pass on their variations to the next generation. This natural selection for specific variations by the changing environment leads to changes in a population over time and gives rise to new species as illustrated in the following diagram.



11. What evidence is there for life-forms being very different at various stages in the Earth's history?

12. The source of all variations in any species is the mutation of existing genetic material or DNA. What is a mutation?

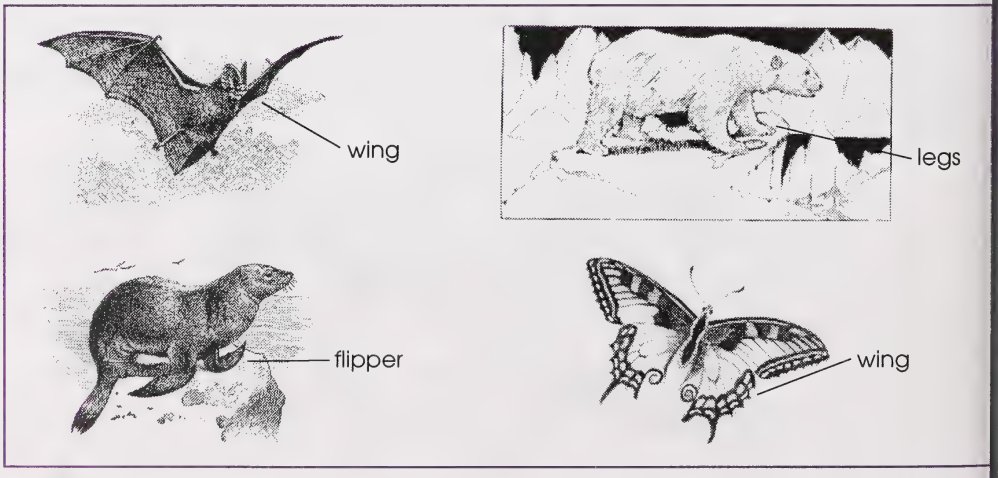
13. Look at the various breeds of dogs shown in Figure 4.4 in Activity 1 of this section. Explain how it is possible that such a large variety of dogs could come from one common stock of animal.

Natural selection is the driving force of evolution and was first proposed by Charles Darwin in 1859. For speciation to occur there must be isolation of two or more groups of a population so that they do not reproduce. This is achieved when groups are physically isolated due to geographic changes. Once isolated, the movement of genetic variations from one group to the other stops. If selection pressures are different for each group, then each will undergo different adaptive changes leading to new species over time. Such adaptive changes are expanding and leads to a variety of species showing similar structural features modified to serve different functions. Such structures are said to be homologous.

There are many examples of nature inventing structures that serve the same function more than once. Such structures that evolve independently in different species of organisms to perform similar functions. There structures are said to be analogous.

14. The biotic potential of most species, even the slowest-breeding ones, is surprisingly high. Charles Darwin estimated that one pair of elephants would leave over 19 million descendants in only 750 years. Not all of the offspring, however, survive to adulthood. Far more offspring are generally produced in a population than can possibly survive. Explain why all offspring do not survive, making reference to the struggle for existence.

15. Look at the following pictures. Which of the labelled structures are analogous and which ones are homologous?



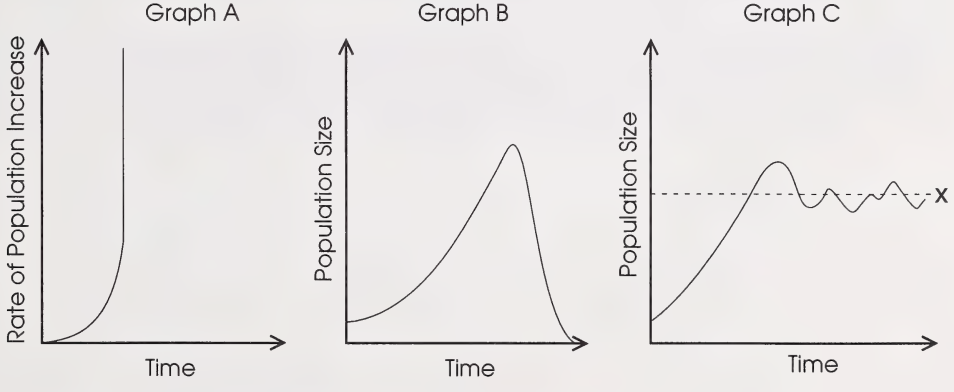
Evolution occurs in populations, not in individuals. Thus, the change in features of a species as it evolves is expressed by the population. Two other features of populations that do not remain constant over time are the individuals that make up the population and the number of its members.

New members are added through natality and immigration, and others are lost through mortality and emigration. These all contribute to the size of a particular population and are themselves influenced by abiotic and biotic factors of the environment. Under ideal conditions, populations grow to the full extent that their biotic environment will allow them, undergoing exponential growth often beyond the carrying capacity of the environment. Then they decline and fluctuate above and below the carrying capacity in response to environmental influences.

The human population is still in the stage of exponential growth, and already pollution and the supply of resources including food are becoming a concern. Since humans are able to alter the environment significantly to meet their survival needs, they are, in fact, increasing the Earth's carrying capacity for the human species. How much the carrying capacity can be extended without disastrous effects to the biosphere and to all life-forms is a question yet to be answered. Much has yet to be learned about humans' place in nature and their niche in its harmonious balance.

16. Variations that provide a competitive advantage to the individuals that possess them are naturally selected for by the environment. Explain how this happens.

17. Study the graphs of population growth and answer the next four questions.



a. Which graph shows low environmental resistance?

b. Which graph definitely represents a closed population?

c. Graph C shows a line X, above and below which the population fluctuates. Explain what this line represents.

d. Which graph represents the present growth of the *Homo sapiens* population?

Check your answers by turning to the Appendix, Section 3: Extra Help.

End of Part B

Enrichment

PATHWAYS

Do either Part A or Part B.

Part A

Science Skills
- ☑ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

Investigation: Variations Among Individuals

Variations occur in every population of organisms including humans. Physical variations are generally more obvious than chemical or behavioural ones, but on closer inspection they may also be noted.

Purpose

You will survey at least ten people in your community to see the variation in a number of human traits.

Materials

- sample of 10 people
- ruler
- tape measure

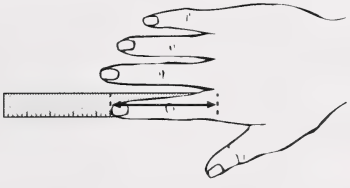
Procedure

- Survey ten people for variation in traits such as listed in the chart in the Observations section of this investigation.

- For features where measurements are to be taken, use a sample of individuals of the same age group or all adults. Indicate all the measurements and the number of individuals of each size.

- For eye and skin colour, list all the colours you find in your sample of people.
- Where individuals either have or do not have the trait, record the number of each in your sample. This includes tongue rolling and blood types.
- Tongue rollers can shape their tongues into a U as shown; non-rollers cannot do this.

- Measure the index finger of your right hand. Place a ruler on a flat surface, and then put your hand on the ruler so that you can measure from the notch between the index finger and the middle finger to the tip of the index finger. Do not include your fingernail in the measurement. See the sketch provided.



Observations

1. Make a data chart like the one that follows and record your findings.

Feature	Trait Variations (Measurements and Observations)
eye colour	
length of earlobe (mm)	
height (cm)	
skin colour	
blood type (A, B, AB, O)	
length of index finger (cm)	
tongue rolling	

Analysis and Interpretation

2. Explain how biologists account for all these variations in the human population.

3. Can you see any competitive or survival advantage in having one or more of the variations listed in the chart? If you do, identify the variation and explain how it would be advantageous to humans in their everyday survival.

Check your answers by turning to the Appendix, Section 3: Enrichment.

End of Part A

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☐ F. Evaluating

Part B

Research the answers to any two of the following questions.

4. a. How do paleontologists determine the age of rocks and fossils so that they can determine when certain organisms flourished on this planet?

   b. From the evidence in fossil records, has speciation occurred gradually (gradualism) or in fits and starts (punctuated equilibrium)? Explain and cite examples.

   c. What other evidence is there for evolution besides the fossilized remains that appear in the sediments?

5. Discuss the role of humans in changing the path of evolution. Use an example.

6. Explain the possible fate of a structure such as the appendix, given that it serves no useful purpose in humans.

Check your answers by turning to the Appendix, Section 3: Enrichment.

End of Part B

Conclusion

The one element of the biosphere that is predictably constant is the element of change. Though the environments of the biosphere appear to be stable and unchanging over the short term, they have not remained static over the course of the Earth's history, and neither have the organisms that occupy them. To survive any biotic or abiotic changes that may arise, species must have the genetic resources that will allow them to survive the process of natural selection accompanying these changes. Genetic variations produced by mutations have accumulated in populations since the beginning of life and they continue to occur even today. This diversification in genetic information has led to the enormous variety of species that exists today.

New environmental elements produce selective pressure that will favour one or more traits, driving evolution of the species in a certain direction. If the necessary variations needed for survival are not in the population, then the species becomes extinct. The fossil record shows that there were many such organisms unable to survive change in the past. Those that did survive were unwillingly changed through the process of natural selection, becoming different from their predecessors. This mechanism is the force driving evolution.

Not only do environments and the organisms living there change over time, but so do populations. Population growth is influenced by a number of factors and tends to undergo predictable changes given certain conditions. Nature has built-in controlling mechanisms to keep populations in check and to maintain a balance. *Homo sapiens* is one particular species that presently is upsetting this natural balance in the attempt to control the environment and to meet the needs of the growing multitudes. Humans must learn to live in harmony with the natural world and to sustain the renewable resources for future generations.

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

MODULE SUMMARY

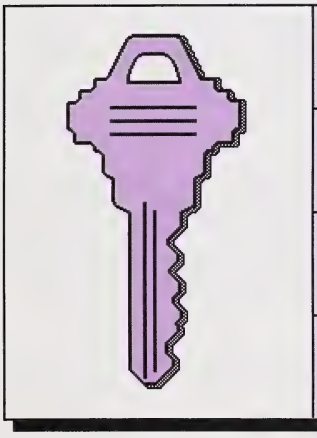
In this module you have looked at biological communities, ecological succession, and changing populations.

You learned that organisms live together in groups known as communities and depend on each other for survival. Some live in special relationships known as symbiotic relationships. You learned that organisms compete with each other both within species and between species. Many organisms use other organisms for food. This is known as predation. Sometimes organisms are introduced to an area where they have never been before. These organisms have no natural enemies in this new area resulting in exploding population numbers. This can harm the habitat as well as other species in the community. Humans are often the cause of species being introduced to a new area.

In Section 2 you saw that communities develop and succeed one another until a final or climax community is reached. The climax community usually lasts for a long period of time unless some catastrophe disrupts it. When succession starts with a barren, lifeless area, it is known as primary succession. When succession occurs after a disruption to an established community, it is known as secondary succession.

In Section 3 you learned about the individual populations which make up a community. Populations change over time adapting to the abiotic and biotic factors of the habitat. The process of natural selection allows those organisms which can best adapt to the abiotic conditions to survive. Nature keeps populations in balance through predation, disease, and food supply. Populations increase, reach the carrying capacity of their environment, then fluctuate above and below this carrying capacity. Humans, however, have learned to overcome these balance checks resulting in an exploding population. Will humans be able to control their exploding population growth before the carrying capacity of the biosphere is surpassed? Or will humans continue to change the environment to support the increasing population? The resources of the Earth are finite; therefore, humans must learn to maintain a sustainable development.

Appendix



- Glossary
- Activities
- Extra Help
- Enrichment

Glossary

adaptation: an inherited trait that enhances an organism's chance of surviving and producing offspring

analogous structures: structures that have a similar function but are quite different in internal structure and evolutionary origin

biotic potential: the maximum rate of reproduction under ideal conditions

carrying capacity: the population an ecosystem can indefinitely support

climax community: the final stage in a successional series that is relatively stable, perpetuating abiotic conditions necessary for its own survival

closed population: a population with artificial boundaries which restrict organism movement in or out such that size is influenced only by birth and death

commensal: an organism that benefits in a commensalism relationship

commensalism: a relationship in which one organism benefits while the other is not affected

community: two or more populations of organisms living together in a defined area

competition: the relationship between two or more organisms when there is a limited amount of resources available

divergent evolution: the evolution of two or more species from one ancestral species whose population became fragmented and genetically isolated such that different selective pressures affected each group

DNA: deoxyribonucleic acid

ecosystem: a community interacting with its physical environment

fertility: potential for producing offspring

fitness: the reproductive success of an organism

gene: a section of a DNA strand that controls a specific trait

gene pool: the total of all the different kinds of genes in a population

geographical isolation: the physical separation of a population into two or more groups so that the groups cannot interbreed; results in genetic isolation

gradualism: the view that slow, continuous change in organisms has led to profound cumulative changes over long periods of time

heritable variations: characteristics that are past from parents to offspring

homologous structures: structures of similar origin that serve different functions

interspecific competition: competition between organisms of different species

intraspecific competition: competition between organisms of the same species

microclimate: localized climate slightly different from the surrounding area, produced by factors such as topography or vegetation

mortality: the death rate in a population

mutation: a change in DNA structure which alters a particular trait

mutualism: a relationship in which both organisms benefit from living together

natality: the birth rate in a population

natural selection: a process whereby individuals possessing certain variations are able to survive more successfully, produce more offspring, and thus increase the frequency of these favourable variations in subsequent generations

niche: the way an organism makes use of the biotic and abiotic resources in its environment, what it eats, how it gets its food, where it lives, and how it interacts with other organisms and its environment

open population: a natural population which varies in size over time because individuals not only are born and die but are also free to immigrate or emigrate

parasitism: a relationship in which one organism benefits while the other is harmed

predation: the relationship between two organisms in which one uses the other as a food source

prey: an organism that serves as a food source for a predator

primary succession: the replacement of one community by another until a final, stable climax community is established where no life existed before

punctuated equilibrium: the view that evolution is not uniform in rate but instead involves spurts of relatively rapid change followed by long periods of genetic stability

secondary succession: the process of one community succeeding another until a climax community is reached in a region that has been disrupted by factors such as fire, flood, or human activities

speciation: the formation of one or more new species through genetic isolation

species: a group of organisms that live together, share common traits, and interbreed under natural conditions

succession: the gradual replacement of one community by another until a stable climax community becomes established

survivorship: a measure of how many organisms in a population reach a certain age

symbiosis: a close association of two organisms in which one or both benefit

Suggested Answers

Section 1: Activity 1

1. A community is defined as a group of plants or animals living under relatively similar conditions in a defined area.

2. Two differences are as follows:

   - The human community consists mainly of people and few other organisms whereas the natural community has a greater diversity of life.

   - The environment in the human community has been modified to suit the needs of people and has become unsuitable for most other organisms that live in this region.

   The major similarity is that both communities have living things in them.

3. Depending on where you live, you could have one or more of the following communities:

- slough
- stream
- aspen forest
- willow wetland
- grain field
- lake
- marsh
- spruce forest
- mixed forest
- rotting log
- pond
- grassland
- pine forest
- muskeg

4. A community includes only the living things whereas the ecosystem includes the living things and the physical or non-living components of the environment.

5. The different species in this natural community include ground squirrels, coyotes, hawks, grasses, and other vegetation.

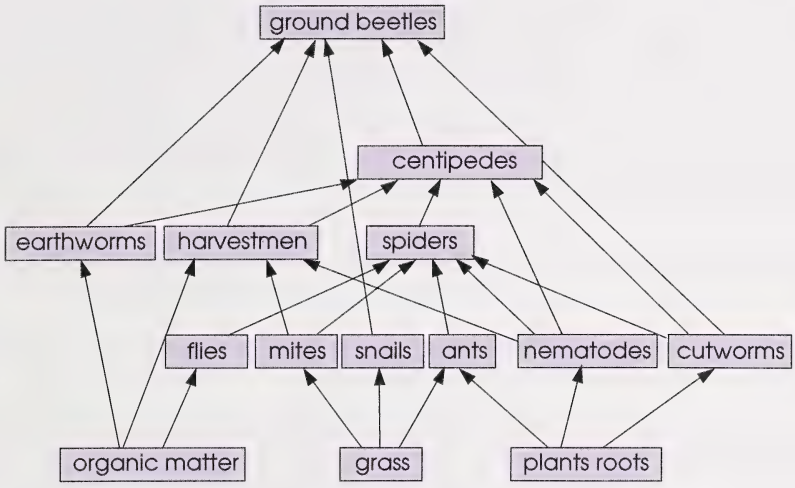
6. Abiotic factors would include temperature range, amount of sunlight, type of soil, amount of precipitation, relative humidity, amount of wind, altitude, and topography (slope and drainage of the land).

7. Here is a sample of the results you might obtain.

Temperature (°C)	pH
10°	6.8

Common Name of Organism	Number Collected	Common Name of Organism	Number Collected
spiders	3	harvestmen	5
earthworms	1	slugs	1
centipedes	2	grass	2
ground beetles	2	clover	1
ground beetle larvae	1	aster	1
mites	25	bacteria	countless
ants	10	protozoans	thousands
spring tails	30		

8. **Textbook question 1:** Here is one food web you might be able to make from organisms typically found in soil.



Textbook question 3: The earthworm eats soil, passes it through the intestine, digests the organic matter and excretes the remains as castings. It is amazing to realize that most of the Earth's soil passes through the intestine of an earthworm at one time or another. This is because earthworms are so numerous.

Textbook question 4: The upper layers of soil contain most of the organic remains of plants and animals. The decomposers feed on this organic matter.

Textbook question 5: Plants contribute most of the organic matter to soil in the form of leaves and entire plants such as grasses and weeds. This plant material forms humus which helps to retain soil moisture and prevents compaction of soil particles. The roots also bind the soil together preventing soil erosion by wind and water. Litter also dissipates the energy of falling rain, allowing the moisture to seep into the soil pores without compacting the soil in the process. Vegetation also slows the wind velocity near the ground, reducing the chance of wind erosion.

Textbook question 6: The two main benefits to soil are as follows:

- Organic matter increases the water-holding capacity of the soil.
- Organic matter is rich in nutrients.

Textbook question 7: Animals contribute solid and liquid wastes to soil which replenish the soil nutrients. Plant roots help to break up rocks as they grow into rock cracks. Plant roots also secrete mild acids which help to chemically break rocks into soil particles. Decomposers break organic matter consisting of dead plants and animals down into humus which, together with the rock particles, makes up soil.

9. Refer to the answers provided in Section 1, Activity 1, question 8.

Section 1: Activity 2

1. The relationship between the clown fish and the anemone can best be described as mutualism since both organisms benefit. The clown fish receives protection while the anemone benefits from the decoy action of the clown fish.

2. One mutualistic organism that lives in humans is the bacteria *Escherichia coli*. These bacteria live in the large intestine of humans and feed on undigested food matter that the host would normally excrete. In turn, *Escherichia coli* prevent disease-causing bacteria from establishing in the human intestine, and they produce vitamin K which is essential to humans.

3. The type of symbiotic relationship that exists between these two organisms is called commensalism because the shark is unaffected while the remora benefits with a free ride and tasty morsels.

4. The symbiotic relationship between humans and the amoeba is called parasitism since the amoeba feeds on human intestinal walls, causing harm to the human host.

5. There is a transfer of energy from the host to the parasite, resulting in less energy being stored in the biomass of the next trophic level in the food chain.

6. Your completed chart should look like the following.

Type of Symbiotic Relationship	Organism Pairs	Effects of Relationship
commensalism	robin nesting in a poplar tree	One organism is unaffected.
mutualism	cleaner fish and parrot fish	Both organisms benefit.
parasitism	fleas and dogs	The host is harmed.

7. A commensal has no effect on its host and the host seems to be tolerant of or indifferent to the presence of the commensal. In contrast, a parasite has a negative effect on its host.

8. a. commensalism
   b. mutualism
   c. mutualism
   d. i. mutualism
      ii. mutualism
      iii. parasitism
   e. mutualism

9. Parasites such as tapeworms have several stages to their life cycles and the perils of getting from one stage to another are great. Since few eggs are actually successful in completing the cycle and reaching adulthood in a new host, enormous numbers of eggs must be laid to increase the success rate of the species.

Section 1: Activity 3

1. Predation is the situation in which one living organism serves as a food source for another.

2. Predation is an important biotic factor in ecosystems because it helps to keep the prey population down so that it does not reach such high levels that it damages its own food supply or the food supply of others.

3. a. The coloured line represents the predator population.

   b. The black line represents the prey.

   c. There are generally more prey organisms than there are predators because the supply of energy at each trophic level decreases and the predators are at a higher level.

   d. The best year for prey fur would have been about 1863. The best year for predator furs would have been about 1887.

   e. In order for the predator population to increase, there must be more prey. With more food the adults are healthier, more resistant to disease, and better able to survive harsh winter conditions. Offspring are also healthier and more of them survive to adulthood. For this reason, a rise in prey population must come before the predator numbers begin to increase.

   f. The average length of the cycle is about ten years.

4. Here are some sample results. The results of the hypothesis will depend on which hypothesis you chose.

Toothpicks	Number of Toothpicks (Prey) Found		
	Average of Initial Hunt	Average Results of Hypothesis One	Average Results of Hypothesis Two
forest green (dark green)	5		
kelly green (medium green)	12		
grass or olive green (dark green)	22		
natural colour of toothpicks	29		
total (all colours)	68		

5. Your hypothesis statements will vary but should be similar to the following statement. An increase in the number of predators would result in more prey being caught.

6. The test statements will vary but should be similar to the following statement. When more predators (students) were added in the hunt, more of all colours of the toothpicks or coloured paper were found. In particular more of the number of toothpicks (or coloured paper) that did not blend in was found. In the natural habitat when there are more predators in a community, the number of prey taken increases. Those prey that do not blend in with their environment will decrease in numbers the most.

7. **Textbook question 1:** The different colours represent genetic variations in the individuals of the population such that some are better suited to survive because they are more difficult for predators to see.

   Textbook question 2: A balance between the predators and the prey would be maintained as long as there is no significant change in the environment which would give the predator or the prey a significant advantage. The balance could be disrupted by the following:

   - the introduction of an exotic species
   - a disease epidemic in either population
   - overhunting of either species
   - environmental changes, either natural or caused by humans
   - a natural catastrophe affecting one species

   Textbook question 4: The success of the prey depends upon its colour and the relative position of the toothpick on the surface. Those that become hidden by blending well with the background and aligning themselves with the grass stems are most successful in this simulation. Another adaptation that would increase chances of survival is the instinct to remain motionless when in danger. A moving body is much easier to detect visually than one that is motionless.

Section 1: Activity 4

1. The survival advantage of staying together in packs is that packs of wolves can bring down large prey animals such as moose and deer much more easily than a single wolf could.

2. a. As more willow shoots grow, more food is available to the hares and more hares can survive the harsh winters. The litters are also larger when there is more food so the population growth is fairly rapid. As the population continues to increase over several years, the intraspecific competition for food increases. Food is consumed faster than it can be replaced by new growth, so the hares become less healthy, succumbing to disease and predation. The size of the litters decreases, fewer offspring survive, and the population drops off rapidly. Fewer hares means less consumption of willow shoots, so the plants have a chance to regenerate with new growth. This increase in food sets the stage for the next cycle.

   b. Predation helps bring the hare population down. It increases with an increase in the hare population and decreases when the population of hares goes down.

3. a. mates
   b. food
   c. space (territory)
   d. space (light or nutrients)
   e. food

4. a. Aphids kick and shove intruders out of their territory.

   b. Male spruce grouse fluff up their feathers, fan their tails, and peck at objects around them as a threat to intruding males.

   c. Wolves mark their territory with urine, which warns intruders of the territorial boundaries.

5. The niche of an organism refers to its way of life, including where it is found in a community, what it eats, how it gets its food, and how it interacts with other organisms. If the niche of two animals is similar, that means that they may compete for space, or food, or both. This results in interspecific competition.

Section 1: Activity 5

1. The zebra mussel has multiplied quickly because it has very few predators and there is a plentiful supply of food. Because the mussel eats the phytoplankton, the higher trophic levels are affected.

2. The lack of calcium and algae in the other lakes is expected to keep the mussel populations small due to the high competition for these resources.

3. An ecological problem is that mussels compete with other natural algae eaters in Lake St. Clair, reducing their numbers and in turn reducing the populations of commercial fish such as trout, walleye, and bass. Their attachment to rocks makes these areas less favourable for spawning of fish. An economic problem is that mussels attach to the surface of intake water pipes, which restricts water flow for municipal, agricultural, and power generator use. The reduction of trout would also affect the commercial fishing industry and reduce tourism to the area specifically associated with fishing for sport.

4. The following major points should be included in your case study of the lamprey. The adult lamprey was originally restricted to marine and brackish waters of the St. Lawrence River though it spawns upstream like salmon. With the construction of the Welland Canal around the Niagara Falls, the lamprey was able to move into the Great Lakes some time between 1936 and 1946. Being an ectoparasite, it attaches its mouth to the body of a fish and feeds by sucking the tissue fluids. Fish that survive an encounter with lamprey are weakened and succumb to predators or disease. Once in the Great Lakes these ectoparasites quickly increased in numbers, and in the process they virtually wiped out the large fishing industry that once existed there. Before the lamprey invaded the lakes, approximately 6 800 000 kg of lake trout were harvested each year but by 1960 the catch had decreased to 135 000 kg. Various methods of eliminating this pest have been tried, including a selective poison that kills that larvae and the placement of electrically charged screens across streams to prevent the movement of adults upstream for spawning. The use of the poison has had some effect in decreasing the pest's numbers, but there is no way of completely eliminating it from the Great Lakes at this stage.

Section 1: Follow-up Activities

Extra Help

1. Communities may form to satisfy the needs for food, protection, or shelter.

2. A predator-prey relationship such as the one between the wolf and the deer illustrates a community formed on the basis of the need for food. The clown fish and the anemone have a relationship based on the need for protection. Nesting birds illustrate the need for shelter.

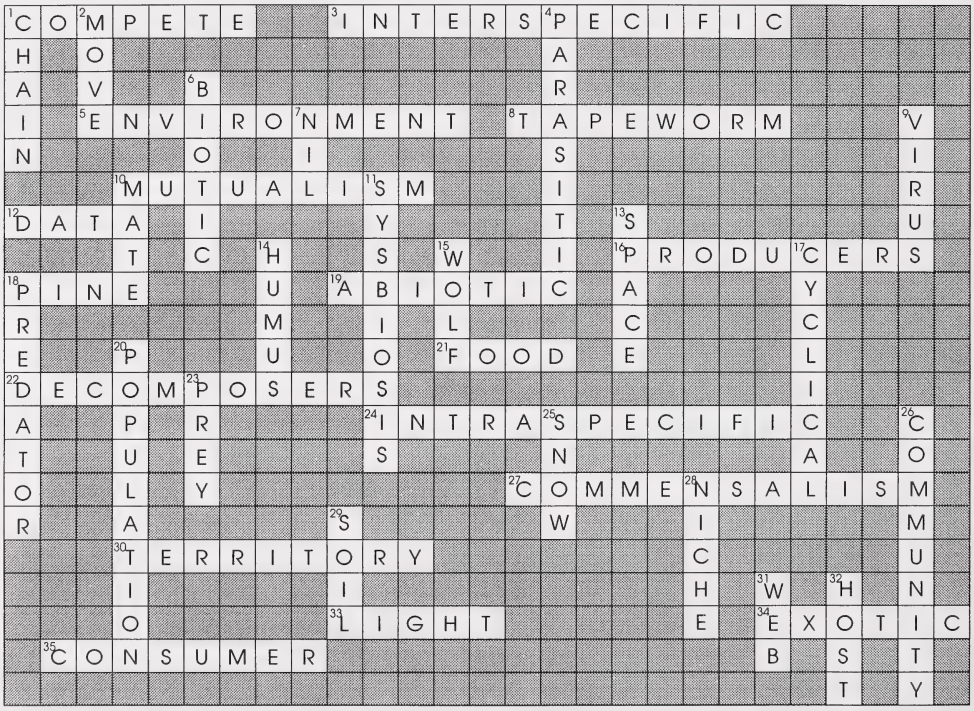
3. Your chart should look like this:

Type of Symbiosis	Description
parasitism	relationship in which one organism benefits while another is harmed
commensalism	relationship in which one organism benefits while the other is unaffected
mutualism	relationship in which both organisms benefit

4. Your completed chart should look like the following.

Ecological Relationship	Effect on Organism 1	Effect on Organism 2
mutualism between 1 and 2	+	+
parasitism by 1 on 2	+	–
commensalism of 1 on 2	+	0
predation by 1 on 2	+	–
competition between 1 and 2	–	–

5. The solution to the crossword puzzle is as follows:



Enrichment

1. The tapeworm has hooks and suction cups to hold it in place when wastes are excreted. The worm also absorbs its food directly though its skin.

2. Diffusion is the process by which nutrient molecules cross cell membranes from areas of high concentration to areas of low concentration.

3. The worm is hermaphroditic which means that is has both male and female sex organs. It can fertilize its own eggs.

4. The last segment of the worm separates from the rest of the worm when the eggs in it are mature. This segment is expelled to the outside with the wastes of the host organism.

5. The tapeworm has a tough outer coat called a cuticle which cannot be digested, so the worm is safe from the digestive enzymes around it.

6. Your completed chart should look like the following.

Organism	Habitat	Ecological Relationship with Humans	Human Impact on Population	Human Activity Causing Change in Organism Population
mallard duck	slough	predation	decrease	draining of sloughs and other bodies of water, destruction of nesting sites around sloughs
aspen and spruce	forest	competition (for space)	decrease	slashing and burning for agriculture purposes, cutting for logs or pulp
ground squirrel (gopher)	grassland	competition	decline	cultivation of land which is normally the gopher habitat
whitetail deer	mixed forest and open grassland	predation	increase	partial deforestation creating a more suitable habitat for deer

7. Answers will vary. Your answer should include the major points on how the species was introduced as well as how it affected the ecosystem. Include the economic effects as well as what has been done to try to reduce the numbers of the exotic species.

Section 2: Activity 1

1. spiders → algae → mosses and ferns → flowering plants and grasses → shrubs and trees → insects, reptiles, snails, and birds

2. Larger plants and trees took root in the soil.

3. The natural process of sequential change in community structure leading to changeover of communities until a final stable climax community becomes established is called ecological succession.

4. Sample observations are as follows.

NAME OF ORGANISMS	NUMBER OF ORGANISMS EACH DAY							
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Bacteria: Aerobic Forms	4.1×10^3	8.7×10^3	1.3×10^4	1.2×10^4	9.6×10^3	8.1×10^3	4.7×10^3	1.2×10^4
Anaerobic Forms	3.7×10^2	7.5×10^2	1.5×10^3	1.9×10^3	4.2×10^3	7.9×10^3	1.4×10^4	2.0×10^4
Blue-Green Algae: *Nostoc*	18	47	32	8	2	0	0	0
Green Algae: *Spirogyra*	0	0	2	13	19	15	4	0
Zygnema	0	0	6	18	28	20	2	0
Protozoans: *Hateria*	6	27	32	17	3	0	0	0
Vorticella	3	5	9	11	8	1	0	0
Diatoms: *Navicula*	0	0	4	17	33	28	19	6
Rotifers: *Philodina*	0	6	14	35	51	26	8	0
Misc. Invertebrates:								
Nematode worm	0	0	0	0	1	3	2	0
Bristle-worm	0	0	0	0	0	0	1	3

5. Here are some sample results.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Colour	C	G	G	G-B	G-B	G-B	B	B
Temperature (°C)	15	16	16	17	17	18	20	20

6. **Textbook question 1:** There are a number of examples of succession in the hay infusion. Blue-green algae are numerous in the early stages of growth only to decline in numbers and to be replaced by the green algae within a few days. Several of the protozoans such as *Halteria*, *Chlamydomonas*, and *Chilomonas* appear early in the successional stages, while *Tubifex* (sewage worms) and nematodes appear much later.

Textbook question 2: The various species of bacteria were the food for specific protozoans and had to appear first in order for the predators to survive. In addition, the water turned brownish-green, reducing the light intensity that could penetrate the infusion. This may have produced suitable light conditions for some species.

Textbook question 3: Aerobic species of bacteria and blue-green algae first became dominant. Generally, they seem to decline in number rather than disappearing suddenly.

Textbook question 4: The organisms that appear suddenly in the infusion are able to form a resting stage or spore when conditions become unfavourable. These spores break open when conditions become suitable, releasing the active stage of the species and making it appear suddenly where it was not to be seen a short time before.

Textbook question 5: Any organisms that did disappear would have done so because they died or returned to the spore stage as a result of poor conditions such as the intense, hot light of the microscope.

Textbook question 6: There was a noticeable change in the colour and the smell. The initial colour change was due to the increase in numbers of algae which became food for many of the protozoans. The foul smell that appeared later indicated an increase in the anaerobic bacteria activity, which results in decreased oxygen. This made conditions unsuitable for many protozoans, but favourable for the tubifex and nematodes.

Textbook question 7: The climax community was made up of anaerobic bacteria, *Tubifex*, and nematode worms, all of which seem to thrive in the conditions produced after several days. This community should remain unchanged as long as the physical conditions of the infusion remain the same. If it were to dry out or the water were to be changed, then the succession of organisms would begin once more.

7. a. bacteria
   b. *Coleps*
   c. *Oxytricha*
   d. *Chilodonella*
   e. *Chilomonas*
   f. *Halteria*
   g. *Spirostomum*
   h. *Chlamydomonas*
   i. *Colpoda*
   j. *Paramecium Caudata*
   k. *Paramecium Aurelia*
   l. *Paramecium Bursaria*
   m. *Stentor*
   n. *Vorticella*
   o. *Anabaena*
   p. *Nostoc*
   q. *Euglena*
   r. *Ankistrodesmus*
   s. *Navicula*
   t. *Tubifex*
   u. *Philodina*
   v. *Spirogyra*
   w. *Zygnema*

8. Refer to the answers provided in Section 2, Activity 1, question 6.

9. Succession takes place because organisms of younger communities alter the abiotic factors of the environment in which they live, making conditions more suitable for other organisms that eventually replace them.

10. Succession does not go on forever. A climax community of organisms eventually becomes established which stabilizes and perpetuates the environmental conditions it needs to survive.

Section 2: Activity 2

1. Primary succession always begins with new territory and requires the buildup of soil. The process begins with hardy pioneer plants and associated organisms. Secondary succession occurs in areas where a community had already been established but was disrupted or destroyed. Soil already exists to some degree in these areas so pioneer plants are not involved.

2. The processes that contribute to soil formation are weathering, mechanical action of roots (wedging), chemical action of roots (secretion of acids), and decomposition of organic matter which comes from dead plants and animals and forms humus in soil.

3. Lichens are called pioneer plants because they are the first autotrophs to become established in a new area where no plants existed before. They are like the first people to settle in a new country.

4. Primary succession occurs in lakes and ponds. The climax community will be a terrestrial community characteristic of the region. In east-central Alberta the climax community would be aspen forest, whereas in southern Alberta it would likely be grassland.

5. a. primary succession
   b. secondary succession
   c. primary succession
   d. primary succession
   e. primary succession
   f. both primary succession and secondary succession
   g. primary succession
   h. secondary succession

6. There would be fewer species of animals in a burned-out forest because there are fewer niches there. This means that there are fewer varieties of plants available as food and the total biomass of the plants is much less, so fewer animals can be supported by the autotrophs.

7. Your chart should look like the one that follows.

Characteristic	Pioneer Community	Climax Community
number of species (few/many)	few	many
biomass (small/large)	small	large
dominant plant size (small/large)	small	large
number of niches (few/many)	few	many
soil depth (shallow/deep)	shallow	deep
stability (does not change abiotic conditions)	changes abiotic conditions	does not change abiotic conditions

8. Answers will vary. Your report should be clearly written and about one to two pages in length. It should describe the area before and after the changes occurred. Describe what type of succession is occurring and describe some of the succession that has occurred. Predict what further changes will occur and what will be the climax community.

Section 2: Follow-up Activities

Extra Help

1. The sand is washed up on shore by the waves and is blown inland by wind forming the dunes.

2. Drift is anything that is washed ashore by the waves such as dead animals and plant material. This organic matter decomposes and contributes to the formation of humus in the soil.

3. Organisms mentioned in the video include the following:

Plants	Animals	
grass	• grasshopper • lizard	• ant • wolf spider
cottonwood	• tiger beetle • digger wasp	• ant • six-lined skink
pine	• deer	• bumblebee
oak	• opossum • beetle • decay snake	• skunk • grey squirrel
beech-maple	• toad • millipede • snail	• red-backed salamander • box turtle

4. The sand becomes fixed in place by the roots of grasses and other plants. As the plants and animals die, they decompose and the remains contribute to the formation of humus needed to form soil.

5. The cottonwoods shade the soil and preserve soil moisture by reducing soil temperature and evaporation.

6. An index species one that indicates the presence of certain environmental conditions. For example, an index species of clean, unpolluted fresh water in the foothills would be the mayfly larva or the trout. An index species of polluted fresh water would be the tubifex worm or coliform bacteria. An index animal and plant of the cottonwood stage would be the digger wasp and the cherry tree, respectively.

7. a. The beech-maple forest, once established, maintains environmental conditions suitable for its long-term existence.

   b. Abiotic factors of the climax community include shady, cool, humid, and calm conditions beneath the canopy.

8. A blowout is an area of the climax forest which has been destroyed and reduced to the original sand-dune stage. The area will undergo succession once again, eventually restoring the climax forest that was destroyed.

9. a. lichens
   b. weathering
   c. succession
   d. soil
   e. secondary succession
   f. climax community
   g. microclimate
   h. white spruce
   i. primary succession
   j. humus

10. a. primary succession
    b. secondary succession
    c. secondary succession
    d. primary succession
    e. primary succession

11. a. Lichens secrete acids which help to break up rock into soil particles. As lichens die, their remains add organic matter to the loose granules and increase the amount of soil.

    b. Deciduous trees grow roots into rock crevasses, generating pressure which helps to split the rock apart. The trees also drop their leaves each autumn, contributing to the organic matter of the soil. During the summer the leaves produce shade and obstruct the wind, allowing for more calm conditions to exist along the forest floor.

    c. Spruce trees produce the same effects as deciduous trees. In addition, they drop their needles which make the soil acidic.

12. The cones of lodgepole pines need the high temperatures generated by fire to open up so that the seeds can be released.

13. The few species or organisms in pioneer communities are generally small in size; thus, the biomass and energy flow are both small. The variety and size of species generally increases as one progresses through the communities of succession, and there is a corresponding increase in biomass and energy flow. The greatest diversity of organisms and the largest organisms are usually found in the climax community where the biomass and energy flow are greatest.

14. This statement is not absolutely true for all organisms. Although larger terrestrial plants do need soil and could not live without it, there are many bacteria, lichens, and other plants that do not need soil to survive. However, lack of soil would certainly restrict life to simple terrestrial forms.

    Although soil formation will naturally occur through weathering, plant roots do help to break down rock. Good fertile soil, however, does require humus, the organic matter which comes from living things. Therefore, from this perspective, life is most essential for soil rich in nutrients.

Enrichment

1. a. cactus
   b. grass
   c. aspen and pine forest (The spruce would likely disappear.)

2. Raw sewage and phosphates are nutrients that stimulate rapid growth of algae and other aquatic plants. This increase in organic matter leads to a more rapid accumulation of material on the bottom of the lake as these organisms die. This, in turn, leads to a faster conversion of the lake to solid ground on which the terrestrial climax community can thrive.

3. The tundra could take hundreds of years to become reestablished for several reasons, including the following:

    - short growing period
    - slow growth rate
    - nutrient-poor soil
    - harsh winter
    - low number of species

4. Companies in the forestry industry should have some consideration for wildlife. If only one species of tree is replanted where several normally exist, then the niches of many species of organisms would be eliminated and these organisms would not be able to survive there any longer. Humans must learn to live in harmony with nature, allowing all species a place in our natural community.

Section 3: Activity 1

1. Traits that are generally the same in dogs include the following:

   - two eyes
   - two ears
   - tail
   - covered with fur
   - four legs

   Traits that differ among dogs include the following:

   - colour of hair
   - length of hair
   - size
   - body proportions
   - shape of head
   - stance

2. The genetic material, DNA, is the source of variations which can be inherited.

3. A mutation is a sudden change in the structure of DNA. This changed DNA is passed on from parents to their offspring.

4. Sexual reproduction results in new genetic combinations in the offspring. Therefore, the offspring inherit traits from both parents, and this makes them different from their parents.

5. Genetic variation results in different traits in a population. If there were a change in their environment, some of the individuals could be less susceptible to extinction because of their different characteristics.

6. The patterns of colour are quite different.

7. Differences come about through mutation of existing DNA.

8. The traits expressed are controlled by DNA or, more specifically, by genes inherited from the parents.

9. The first source of variation comes from the mutation of genes. Over time these new forms of genes accumulate in the population, generating extensive variation in the traits of the species. The second built-in source of variation among sexually reproducing organisms results from the mixing of genes during reproduction. The contribution of one set of genes by each parent during fertilization results in a new combination of genes; thus, each offspring is different from its parents and even its siblings.

10. Artificial selection is selective breeding of individual plants and animals which possess certain desired traits until a pure breeding line is produced. This technique is useful in producing varieties of plants and animals that have more agricultural or aesthetic value.

11. Here is an example of the kind of results you might obtain.

Individual Birds	Birth Order	Type of Beak	Resistance to Disease	Feather Type	Adaptation Number
W	3	1	1	2	7
X	2	4	2	3	11
Y	4	2	3	4	13
Z	1	3	4	1	9

Individual Birds	Environmental Conditions Number				Survival Index			
	Spring (4 rolls of die)	Summer (3 rolls of die)	Fall (4 rolls of die)	Winter (3 rolls of die)	Sp.	Su.	F.	W.
W	20	13	10	15	13	6	3	8
X	7				−4			
Y	14	16	17	14	1	3	4	1
Z	18	9	14	10	9	0	5	1

Note: Sp. – Spring; Su. – Summer; F. – Fall; W. – Winter

Note: Bird X has a negative survival value and does not survive the spring season. Thus, you do not roll the die for Bird X for the rest of the year.

12. a. The best combination of characteristics for survival would be hatching first, a normal beak, strong resistance to disease, and normal feather cover.

    b. They can survive, but only if the environmental conditions are ideal.

13. **Textbook question 2:** Birth order is not a physical feature inherited from the parents like the other three characteristics.

    Textbook question 3: The young hatched first would have a head start in development and physical strength over those that hatched later. Thus, they would dominate at feeding time and consume more than their share of the food brought in by the parents. This would lead to faster growth and maturity, increasing the chances of survival.

    Textbook question 4: Beaks are specialized for the intake of specific types of food in a particular way. If a bird's beak shape is not suited to getting and eating the food normally consumed, then the bird may suffer from inadequate nourishment and weaken, succumbing to disease or predators.

    Textbook question 5: Some factors are as follows:

    - They may have inherited better resistance from their parents.
    - They may have more food, so they are healthier and more resistant to disease.

    Textbook question 6: In colder climates, good feather cover would be an advantage by reducing heat loss during the winters. This would reduce food requirements and increase the chances of the bird remaining healthy and disease resistant.

    Textbook question 7: Mortality of adults is greatest during the winter, and it is greatest for the young during the summer when they are most vulnerable to predation.

    Textbook question 8: These traits will decline in frequency within the population. The genes for these traits are not being passed on to offspring as often; thus, the number of birds with these genes and traits will decrease over prolonged periods of time.

Textbook question 9: These characteristics increase the chances of survival. Thus, those birds displaying these traits live longer and produce more offspring. More individuals in each successive generation will inherit these traits so these traits will become more prevalent in the population.

14. See answers to questions 12 and 13 in Activity 1 of this section.

Section 3: Activity 2

1. The selective pressure is the presence of DDT in the mosquitoes' environment.

2. The resistance probably resulted from a mutation of a gene in the population some time during the history of the population.

3. Since the mosquitoes have developed a natural resistance to DDT, it seems that the island authorities must devise a new method to deal with the mosquitoes.

4. Natural selection is the selection for certain traits in a population of organisms by the natural environment.

5. Charles Darwin was the first to propose natural selection.

6. In the shady wooded area the dark-coloured type is more difficult for predatory birds to see, but the lighter-coloured ones stand out. The reverse is true in the open fields where it is brighter. Here the dark-coloured variety is more obvious to birds; thus, they are found and eaten more often than the lighter-coloured individuals.

7. The population in the wooded area would consist mainly of the dark brown, black-banded form because they are more difficult for predatory birds to see. Thus, they have a better chance of survival in the forest than the lighter-coloured varieties. The darker variety then passes on this colouring to more offspring, causing a gradual predominance of this form to occur in the wooded area. In the open field the lighter snails are more fit. Thus, the population there will become predominantly lighter in colour through the same process.

8. The incorrect assumption is that all the flies survive. Some of the eggs would not hatch, many of the larvae would be lost to predation, disease, lack of food, unsuitable abiotic conditions, and so on. The same would be true for many of the adults.

9. By struggle for existence, Darwin meant that since more offspring are generally produced than can survive, individuals of a population must compete for food, space, and other requirements as well as avoid predators. Because there are variations in traits among individuals, some are better suited to survive than others; thus, they survive longer and pass on their variations to more offspring. Better suited means that the individuals have better reproductive success. Survival of the fittest refers to the individual's ability to survive and reproduce.

10. The struggle for existence becomes more intense because competition for food, space, mates, and other requirements increases.

11. In the giraffe population, neck length varied as a result of mutations to genes that control this trait. If food supplies became limited on lower branches of trees that giraffes eat, then the longer-necked individuals would have the advantage of reaching leaves that the animals with shorter necks could not reach. Under these conditions, longer-necked giraffes were better nourished so they survived and reproduced, while their shorter-necked counterparts starved or were too weak to compete for mates. More of the ensuing offspring inherited longer necks. This natural selection for longer necks gave rise to the present long-necked form of giraffe.

12. Before the Industrial Revolution, the white variety was more fit than the black one because they were more likely to survive and reproduce. The use of coal during the revolution resulted in the release of soot into the air, which then collected on the surface of tree trunks where the peppered moth rests during the day. Now the black-coloured individuals are more difficult for predatory birds to see, while the white moths stand out against this dark background and are more easily detected by birds. As a result, the black-coloured variety became more fit and produced more offspring which eventually led to a predominance of this colour in the population.

Section 3: Activity 3

1. One population of fish exists in a large lake. The lake partially dries up and becomes separated into two lakes. This isolates the two populations of fish geographically such that no interbreeding is possible. Differing selective pressures in each lake result in new adaptations in each population such that each population changes genetically. If the genetic differences between the two populations become large enough, the two populations of fish may become separate species.

2. Selection pressure includes factors such as competition, predation, and environmental conditions that cause natural selection of specific traits in a population. Over time these traits become more and more different between two populations of the same species so that these two populations become two distinct species.

3. a. The factor that produced geographical isolation of the squirrel population is the formation of the canyon or the process of erosion that produced the canyon.

   b. They became different because they were genetically isolated. Since relative pressures were different on each side, the traits which evolved were different, leading to enough genetic change that the two groups became separate species.

   c. Yes, they are separate species because they cannot interbreed.

4. Reproductive isolation is the inability of individuals from one population to successfully breed with members of another population of the same species. Reproductive isolation occurs after members of two populations have acquired different adaptations while being geographically isolated such that they are not able to interbreed even when brought together.

5. a. Feather colour and beak shape vary among the different finches.

   b. The competition for food among birds forced individuals to take advantage of any food source available. Since there were variations in the beak shape among individuals of the original population, those with heavier beaks were able to turn to seeds for food. Others with longer, pointed beaks consumed insects that they found in different places and in different ways. The darker colour was advantageous near the ground, whereas the lighter colour was best for survival in the upper parts of trees.

6. The number of toes decreased from four to one.

7. **Textbook question 1:** Each of the modern animals have adapted in the following way.

- The cat has soft pads on its feet to muffle sound made by the foot while stalking prey. It has sharp claws for climbing trees and for securing hold of prey.
- The whale has enormous flippers for swimming.
- The bat has elongated digits forming a framework across which skin is grown to form a wing for flight.
- The horse has one elongated digit which increases the length of the foot and increases running speed.
- The lizard has sharp claws and powerful legs to escape predators by climbing and running with quick bursts of speed.
- The bird has forelegs modified into wings.
- The human foreleg is modified into an arm and a hand with an opposable thumb which allows for enhanced manipulative skills.
- The frog's legs are specialized for jumping on land and swimming in water.

Textbook question 2: The primitive animal skeleton most closely resembles the leg of the lizard. The shorter digits and the short leg bone indicate short powerful legs that likely kept the organism on the ground.

Textbook question 3: Genetic variations of this basic primitive design led to different ways of using the structure. The elongated digits, such as those of the bat, provided a framework for flaps of skin forming wings. Individuals with this kind of forelimb could glide from danger and may have had an advantage in survival. In another case, the bone framework was suitable for the attachment of feathers giving rise to a different form of wing with the same functional advantage as the former type. In the case of the species that relied on speed to escape enemies or to catch their food, the ones with variations which increased the length of the legs were selected for because they were faster. Natural selection for this kind of leg eventually gave rise to the present leg of the cat and the horse. In the case of those animals that did not use the limb for walking but instead used it for another purpose, the variations that were most useful were quite different. The human hand evolved because hominids were tree dwellers. Those with an effective grasping hand required to grab onto tree branches as these primates moved through the tree canopies must have survived better than those without this kind of appendage. As for the whales, those with elongated digits that gave a framework for flippers were selected for because the larger flipper must have made swimming more efficient.

8. The bird's wing and the fly's wing are analogous. They are both used for flying, but the wings are very different in structure.

9. Analogous structures and homologous structures are somewhat opposite in what they are. In analogous structures, the function of the structures is similar while the structures themselves are quite different. In homologous structures, the structures are similar while the functions are different.

10. Homologous structures have evolved from one common structure. This is a spreading or diverging process. Analogous structures involve a common function coming from several different structures. This is a coming together or converging process.

Section 3: Activity 4

1. a. Natality is population change through birth.
   b. Mortality is population change through death.
   c. Immigration is the movement of individuals into a specific region.
   d. Emigration is the movement of individuals out of a specific region.

2. Natality and immigration both increase the population, and mortality and emigration decrease the population.

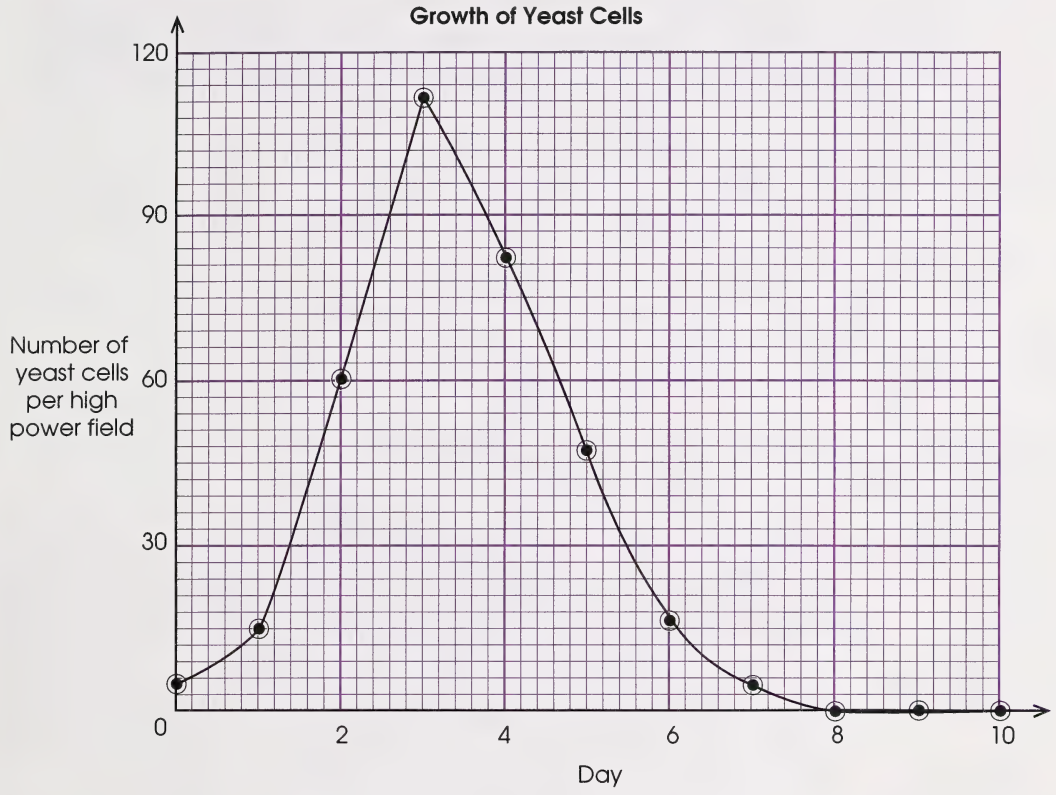
3. a. closed population
   b. open population
   c. closed population (There are fences enclosing the park.)
   d. open population

4. Pyramid A is increasing; Pyramid B is increasing; and Pyramid C is decreasing.

5. Here is an example of the results you may have obtained.

Count	Number of Yeast Cells Each Day										
	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
first	263	16	64	112	86	43	19	4	0	0	0
second	247	17	58	124	74	38	15	6	0	0	0
third	250	14	61	96	81	44	17	5	0	0	0
fourth	235	15	62	108	78	50	21	1	0	0	0
fifth	255	16	55	116	91	36	9	7	0	0	0
total	1250	78	300	556	410	211	81	23	0	0	0
average	250	15.6	60	111.2	82	42.2	16.2	4.6	0	0	0
dilution	$\frac{1}{50}$	1	1	1	1	1	1	1	1	1	1
number of yeast cells per high power field (average × dilutions)	5	15.6	60	111.2	82	42.2	16.2	4.6	0	0	0

6. A sample of the graph from one group should look similar to this. Graphs from other groups should be similar with a peak somewhere around days 3 or 4.



7. **Textbook question 1:** The growth rate is slow from Day 0 to Day 1. Then, it accelerates rapidly during Days 2 and 3 reaching a peak on Day 3. After that, it declines fairly rapidly until it reaches zero again.

Textbook question 2: There should be a general trend showing the initial characteristic exponential growth rate until the population peaks. This is then followed by a slow decline that accelerates into a more rapid decline in the population until it reaches zero.

Textbook question 3: There would be no growth of a yeast population in Flask B since no yeast cells were introduced at the start of the experiment. However, since the flask is exposed to the air, it may develop a large population of bacteria which you could see under the high power of the microscope.

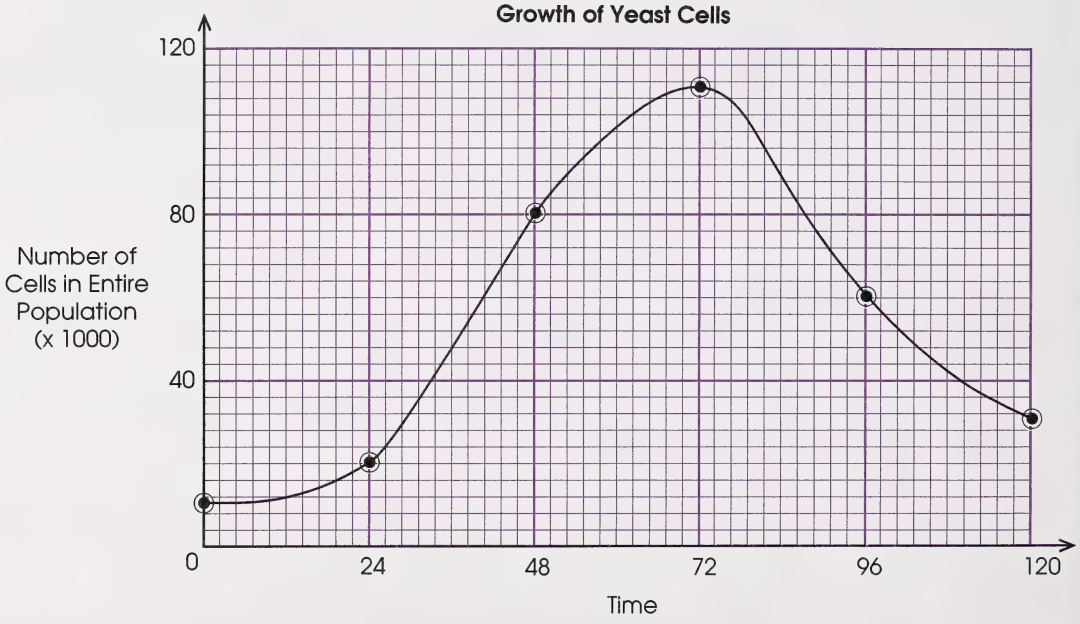
Textbook question 4: Answers will vary depending upon your original hypothesis. You may have hypothesized that the population will grow at a steady rate because reproduction would generate a number of offspring proportionate to the number of yeast cells that would die at any one time. This type of result would give you a straight-line graph. You may have hypothesized that the population would reach a peak and level off when competition for food was greatest, causing death of yeast cells to equal natality. This would result in a graph that flattened out after it peaked.

Textbook question 5: The temperature of the room, the size of the flask, and food availability would be three critical factors influencing growth of the yeast population. Here are some sample results.

8. The following chart gives counts for the sample data.

Hours	Area A	Area B	Area C	Total	Average	Entire Population
0	9	10	11	30	10	10 000
24	21	20	19	60	20	20 000
48	79	80	81	240	80	80 000
72	109	114	107	330	110	110 000
96	57	58	65	180	60	60 000
120	32	29	29	90	30	30 000

9. Your graph should be similar to the one that follows.



10. Growth of the population was slowest from 0 h to 24 h. Growth was fastest between 24 h and 48 h.

11. Every yeast cell reproduces by budding, a rapid form of asexual reproduction in which new individuals begin as small outgrowths of the main cell and grow into complete cells which eventually pinch off to form separate yeasts. With this kind of reproduction, doubling of the population is easily attained when conditions are ideal and all yeast cells are surviving. Also, there is a large amount of available nutrient at the start.

12. Available food is beginning to decline and the accumulation of wastes is beginning to contaminate the environment. Both of these are biotic factors. The abiotic factors should have remained the same.

13. a. The rabbit was introduced to Australia around 1850.

    b. There is exponential growth on the graph from B to C.

    c. The introduction of a viral disease called myxomatosis was the cause of the decline.

    d. The population of rabbits after 1960 has a resistance to myxomatosis whereas the population before 1960 generally did not. Otherwise, all the rabbits would have died in 1960.

14. The three factors that affect biotic potential are the age at which individuals are fertile, the number of offspring produced each time, and the death rate.

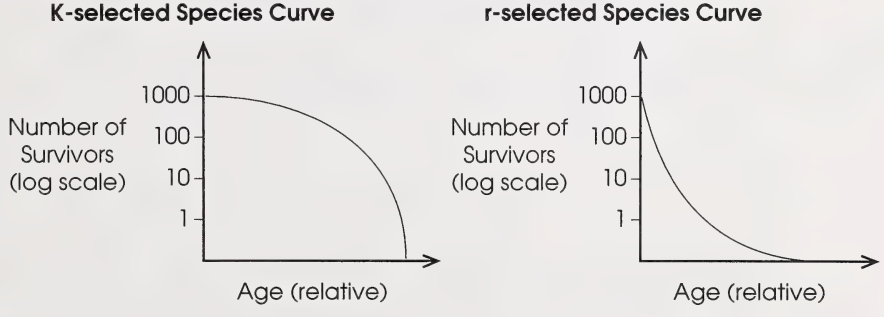
15. a. The carrying capacity is the maximum population size that can be supported by the available resources in an environment.

    b. The available food supply and the space can only support so many rabbits, so if the population exceeds the carrying capacity of the environment, competition for these resources increases and fewer rabbits survive due to the increased stress. Also, the predator population will rise in proportion to the rabbit population; thus, a greater number of rabbits will be removed by predators. All of this brings the rabbit population down below the carrying capacity. This results in more available food and space, so the environmental resistance decreases and the population begins to rise again.

16. The whitetail deer is the K-selected species and the mosquito is the r-selected species.

17. The r-selected species are small, have short life spans, have high reproductive rates, and generally do not raise their offspring. The K-selected species are large, have long life spans, have low reproductive rates, and do raise their young.

18. The survivorship curves are shown in the following graphs.

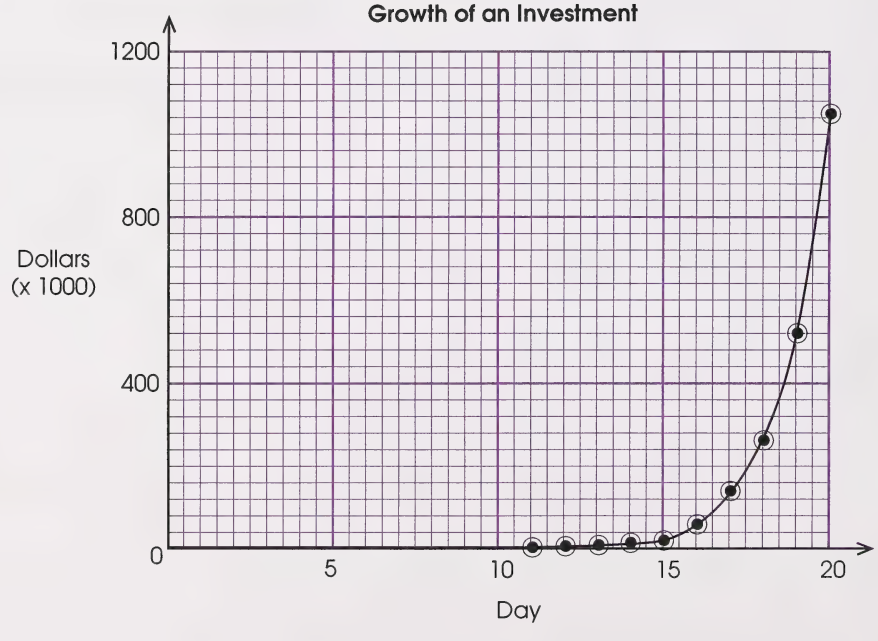


Section 3: Activity 5

1. Your chart should look like the following:

Day	Amount ($)	Day	Amount ($)
1	2	11	2048
2	4	12	4096
3	8	13	8192
4	16	14	16 394
5	32	15	32 768
6	64	16	65 536
7	128	17	131 072
8	256	18	262 144
9	512	19	524 288
10	1024	20	1 048 576

2. The graph of the results is as follows:



3. The amount of money doubles every day.

4. You make the most of your money during the last five days.

5. You would become a millionaire on the last day.

6. The growth of the human population and the growth of the money show the same exponential growth pattern.

7. The human population must level off at some point in the future.

8. The human population remained low because of disease and the lack of machines that help to produce large quantities of food.

9. The bubonic plague killed millions of people and caused the dip in the graph line.

10. The capacity is difficult to predict, but is probably less than 10 billion.

11. a. It took 125 years to go from 1 billion to 2 billion. It took approximately 40 years to increase from 2 billion to 3 billion.

    b. Less and less time is required to increase the population by 1 billion.

    c. The availability of food likely will be the limiting factor.

    d. In the industrialized world, it likely will not undergo the regular fluctuations because humans can alter their environment to suit their needs and they are no longer subject to extremes in diseases and food shortages. In third world countries more extreme fluctuations may occur.

12. They alter their environment for agricultural purposes, for a place to live, and to extract or remove natural resources such as minerals and trees required for production of various products.

13. **Textbook question 1:** Opinions on whether the benefits outweigh the negative effects will vary. Examples of both benefits and negative effects should be included. Signs of strain should include examples such as the following:

    - over fishing off the east coast
    - fish in Alberta rivers such as the Athabasca are showing high levels of various pollutants
    - acid rain in various parts of Canada including Alberta

    Textbook question 2: Most of the world trade involves individual countries. Each country tries to be competitive in terms of the products it produces. This competitiveness may be overcome as countries move toward group trade pacts such as the European Economic Community and the North American Free Trade Agreement (NAFTA).

14. a. The end result could be a massive decline in population and possible extinction of humanity due most likely to pollution of the environment.

    b. Some possible solutions to the negative human impact on the environment are as follows:

    - Reduce human population growth to zero as quickly as possible.
    - Reduce production of waste by recycling and reclaiming.
    - Minimize production and use of products harmful to the environment such as CFCs, PCBs, and heavy metals.
    - Replant forests and establish more natural reserves for wildlife.
    - Minimize the use of vehicles by walking, riding a bike, or taking a bus whenever possible to reduce production of greenhouse gases such as CO_2.

Section 3: Follow-up Activities

Extra Help

1. The solution to the crossword puzzle is as follows.

1 S	P	E	C	I	E	2 S								3 F	I	N	D		
E						4 P	O	P	U	L	A	T	I	O	N				5 F
L			6 L	I	F	E								S					E
E						C								S					C
7 C	O	M	P	E	T	I	T	I	O	N				8 I	9 N				U
T						A					10 I	11 S	O	L	A	T	I	O	N
12 I	N	H	E	R	I	T	E	13 D				I			T				D
O						I		A				Z			A				I
N			14 M			O		R				E			L		15 E		T
	16 I		17 O	P	E	N		W							I		V		Y
	M		R				18 F	I	T	N	E	S	S		T		O		
	19 M	U	T	A	T	I	O	N						20 C	Y	C	L	E	
	I		A				R										U		21 E
	G		L		22 H	O	M	O	23 L	O	G	O	U	S			24 T	A	R
	R		I		E				I						25 H		I		A
	A		26 T	R	A	I	T		T		27 A	28 N	A	L	O	G	O	U	S
	T		Y		V				T			A			M		N		
	I				Y				L			M			O				
	O					29 D	I	V	E	R	G	E	N	T					
30 D	N	A																	

2. Members of a single population look alike, produce fertile offspring when interbreeding, have the same habitat, requirements, and functions, and tend to live together.

3. A population is a group of any species that inhabits a particular area at a particular time. Check the definition on page 576 of your textbook.

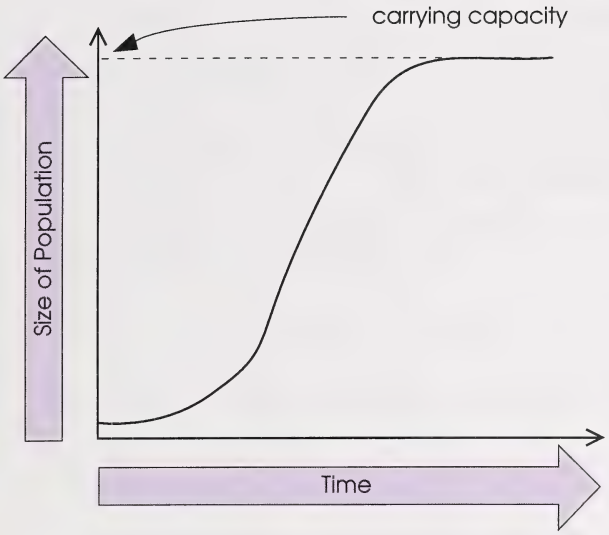
4. Winter severity, predation, availability of nutrients, and availability of winter range will all limit population numbers. Many other factors may also play a role.

5. The two terms used to describe the patterns of dispersal of population members are as follows:

   - uniform (spread out evenly throughout the ecosystem)
     This term may apply to large areas such as the population of grizzly bears in Alberta.

   - clustered (grouped close together, such as in herds)
     This term is usually applied to populations in smaller areas such as the bison in Elk Island National Park.

6.



7. Disease, behavioural interactions, and migration can control populations.

8. Three examples of human intervention are as follows:

   - the removal of excess bison from the population at Elk IslandNational Park to prevent habitat destruction by overgrazing
   - the reintroduction of the swift (kit) fox on the prairies
   - the stocking of mountain lakes and streams with trout

9. Thomas Malthus said that the human population can increase much faster than its space or food supply.

10. In the video, shortages of food, energy, and space are described as limiting factors. You can imagine others such as war or disease. Most likely a combination of limiting factors will play a role.

11. Fossils which have been unearthed show that life has been very different at various stages in the Earth's history.

12. A mutation is a heritable chemical change in a gene or section of DNA which alters the genetic information encoded in the DNA.

13. These variations have been produced artificially by humans selecting for the traits that are preferred. Animals possessing the desired traits are selectively bred to produce individuals with pure breeding for those traits.

14. The offspring must compete for required resources to survive and they must avoid their enemies. This results in a struggle for existence. Since there are variations in traits among individuals, some are better suited to survive than others. Thus, many that are not well suited die before they can reach maturity and reproduce.

15. The wings are analogous, while the flippers and the legs are homologous.

16. The individuals possessing the favourable features are better fit, survive longer, and produce more offspring. As a result, more individuals in successive generations will inherit these favourable qualities.

17. a. Graph A shows low environmental resistance. The population is increasing rapidly due to environmental factors not slowing its growth.

    b. Graph B represents a closed population. Organisms could not move out as the population increased. Lack of food and accumulation of wastes resulted in death of the population.

    c. The line represents the carrying capacity of the environment or the maximum number of individuals that can be supported by the environment.

    d. Graph A represents the present growth of the human population. The human population is presently increasing exponentially.

Enrichment

1. The following provides a guideline for your results.

Feature	Trait Variations (Measurements and Observations)
eye colour	The colours could include grey, blue, green, brown, and so on.
length of earlobe (mm)	This ranges from 0 mm to 10 mm or more.
height (cm)	A great range can be expected.
skin colour	This ranges from very white to shades of brown to black.
blood type (A, B, AB, O)	A and O are most common; AB is the rarest.
length of index finger (cm)	This ranges above and below 6.0 cm.
tongue rolling	Most people have this trait.

2. These have resulted from mutations of original genes that control these traits.

3. There is no survival advantage in having any of the variations studied with the possible exception of darker skin colour. With the increase in ultraviolet light reaching the Earth's surface due to the depletion of the ozone layer, darker skin would be advantageous because it is less sensitive to ultraviolet light which causes skin cancer. Whether more people with lighter skin colour are going to die before they can reproduce remains to be seen since humans can cover up exposed body parts.

4. a. Paleontologists use radioactive isotope dating techniques. Because radioactive isotopes decay at a constant rate not affected by temperature or pressure, the isotope concentration in rocks acts as an internal clock, measuring the time since the rock was formed. For fossils or rocks less than 50 000 years old, the ratio of C-12 to C-14, with a half-life of 5568 years, is measured. (Note: C-12 and C-14 may be written as $^{12}_{6}C$ and $^{14}_{6}C$.) For older rocks, investigators examine the decay of radioactive potassium 40 into argon and calcium. (The half-life of K-40 is 1.3 million years.) For very old rocks the decay of uranium 238 into lead (half-life of 4.5 billion years) is used. Remember that the half-life of a radioactive substance is the number of years it takes for half of the isotope to change to a more stable substance. For example, if you began with 100 g of C-14, you would only have 50 g left after 5568 years. The other 50 g would have turned into C-12.

   b. The fossil evidence supports the punctuated equilibrium process more than the gradualism theory. It appears that the evolution of most species was a relatively rapid event followed by long periods of genetic stability. Paleontologists rarely find gradual transitions of fossil forms. Instead they often observe species appearing as new forms rather suddenly (in geological terms) and persisting essentially unchanged throughout the course of their existence until they disappear from the fossil records in rocks as suddenly as they appeared. The appearance of the mammals was relatively sudden and it is a good example to support the punctuated equilibrium theory.

   c. Examples of evidence for evolution include the following:

      - the fossil record – When fossils are arrayed in the order of their age, you can see a progressive series of changes.
      - the molecular record – The longer organisms have been separated according to the fossil record, the more differences are seen in their DNAs.
      - homology – All vertebrates contain a similar pattern of organs. This suggests that they are related to one another.
      - development – Humans exhibit characteristics of other vertebrates during development. This suggests that humans are related to the other forms.
      - vestigial structures – Many vertebrates contain structures that have no function but that resemble functional structures of other vertebrates. This suggests that the structures are inherited from a common ancestor.
      - parallel adaptation – The marsupials in Australia closely resemble the placental mammals of the rest of the world, which suggests that parallel selection has occurred.
      - patterns of distribution – The inhabitants of ocean islands resemble forms of the nearest mainland but show some differences. This suggests that they have evolved from mainland migrants.

5. Humans, through artificial selection, have significantly altered the course of evolution for many domesticated species and others found to be useful to man. In addition, scientists have learned to change the genetic makeup of organisms using gene-splicing techniques. Also, the destruction of natural habitats is driving many species to extinction because they cannot survive in the altered environment created by humans.

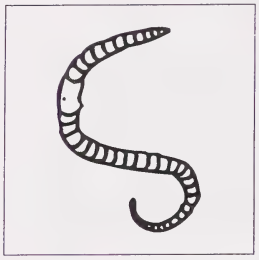
6. Since there is no selective pressure favouring the appendix and no selective pressure against having one, this vestigial structure will remain in the human population indefinitely. For this structure to disappear, the genes for it would have to be selected out of the population, meaning that those with the appendix would be at a disadvantage and would die before they reproduced.

Small Organisms in Soil Litter

The following organisms may be present in a soil sample or a leaf litter sample. The sizes are approximate.

Annelids (segmented worms)

Worms have clearly segmented bodies and no legs.



Whiteworm (2cm)

Earthworm (18 cm)

Molluscs

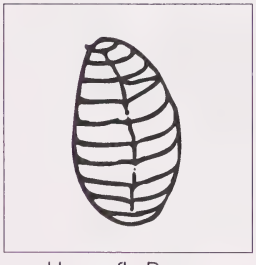
Molluscs are soft-bodied animals usually with some type of shell.

Snail (4 mm)

Slug (4cm to 5 cm)

Arthropods

Arthropods have segmented bodies and jointed legs. Larvae may not have visible legs.



Housefly Pupa

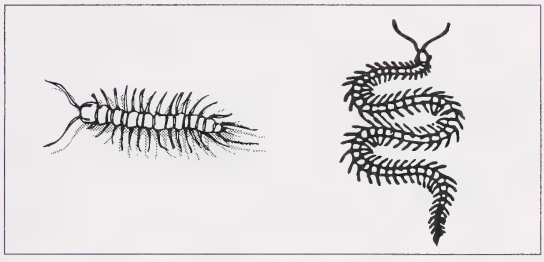
Moth Pupa

Beetle Pupa

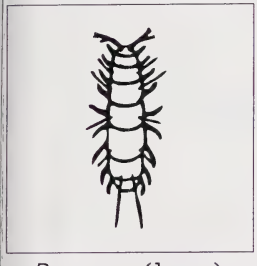
Pill Millipede (1 cm)

Millipede (3 cm)

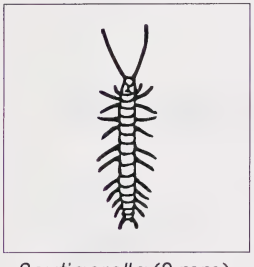
Pill Woodlouse (1 cm)



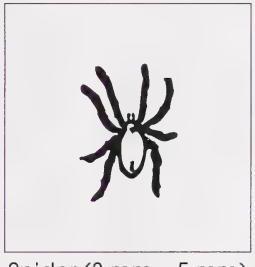
Centipedes (1 cm to 4 cm)



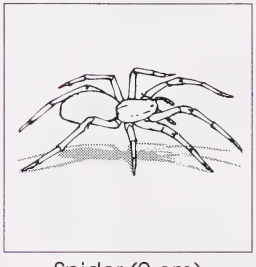
Pauropus (1 mm)



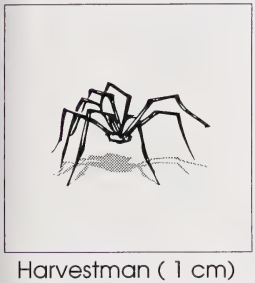
Scutigerella (8 mm)



Spider (3 mm – 5 mm)

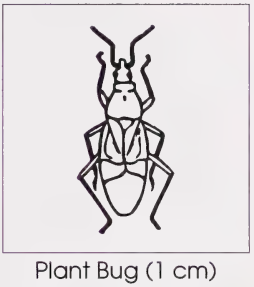


Spider (2 cm)

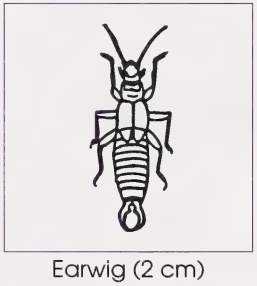


Harvestman (1 cm)

Adult Thrips (2 mm)

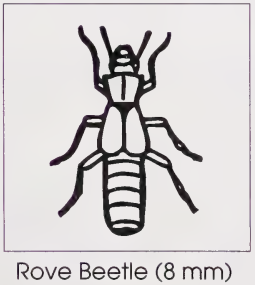


Plant Bug (1 cm)

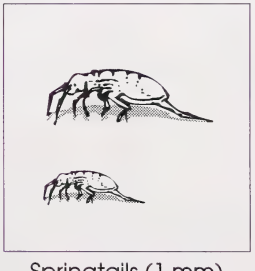


Earwig (2 cm)

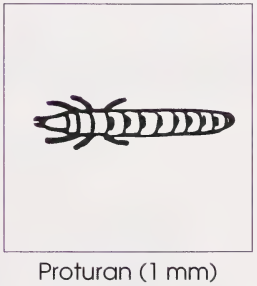
Ground Beetle
(1 cm to 8 cm)



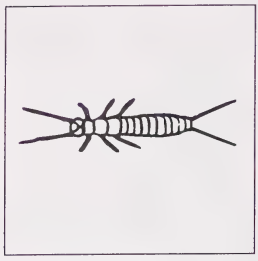
Rove Beetle (8 mm)



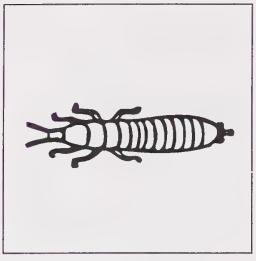
Springtails (1 mm)



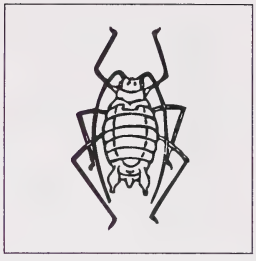
Proturan (1 mm)



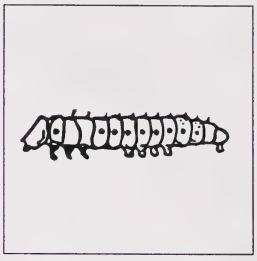
Dipluran (4 mm)



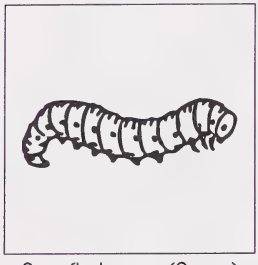
Thrips (1 mm)



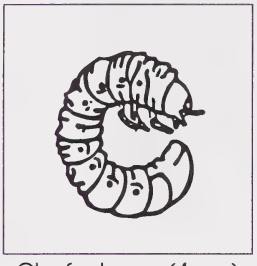
Soil Aphid (4 mm)



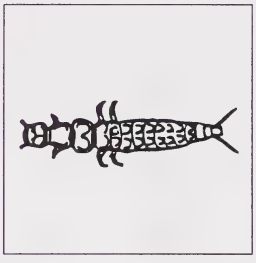
Cutworm (3 cm)



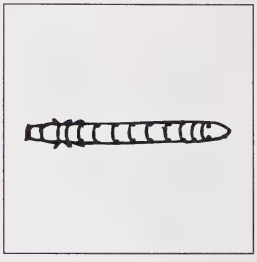
Sawfly Larva (2 cm)



Chafer Larva (4 cm)

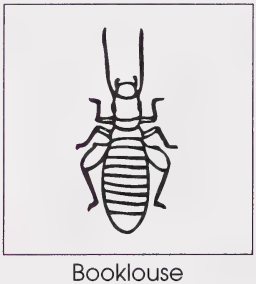


Rove Beetle Larva
(2 cm)

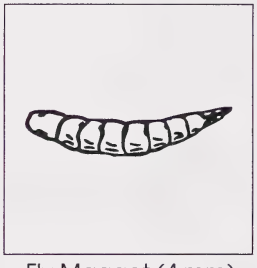


Wireworm
(1 cm to 2 cm)

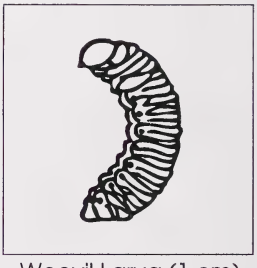
Leatherjacket (4 cm)



Booklouse
(1 mm to 5 mm)



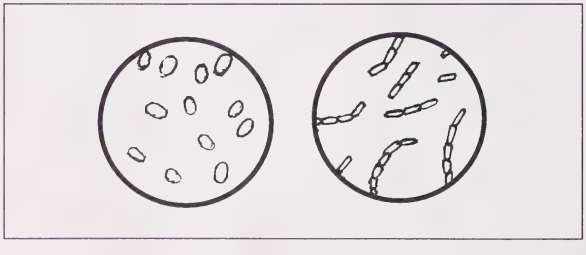
Fly Maggot (4 mm)



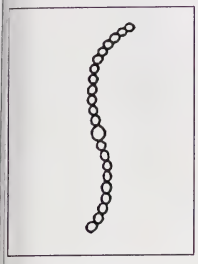
Weevil Larva (1 cm)

Micro-Organisms

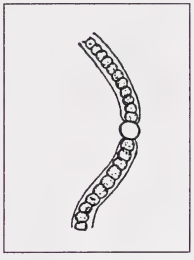
Bacteria

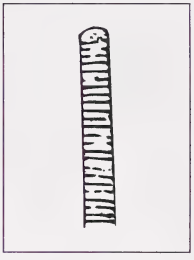


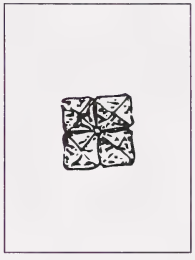
Blue-Green Algae


Anabaena

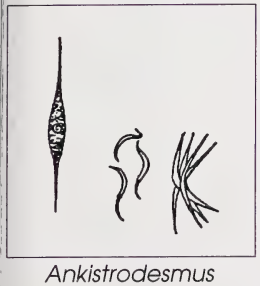

Aphanizomen

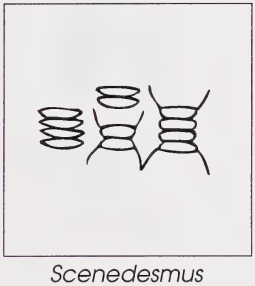

Nostoc

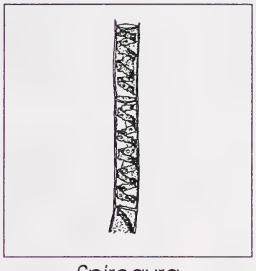

Oscillatoria


Tetrapedia

Green Algae


Ankistrodesmus


Scenedesmus


Spirogyra

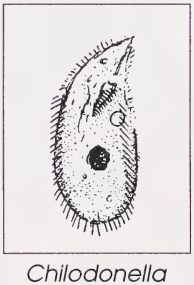

Zygnema

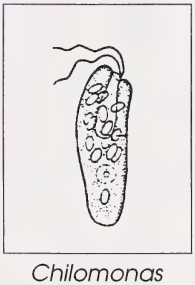
Protozoans


Amoeba

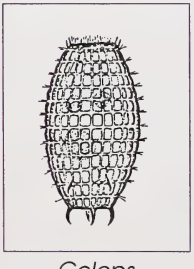

Astasia


Blepharisma

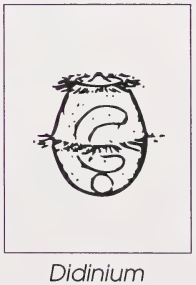

Chilodonella

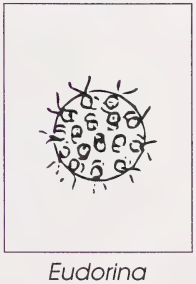

Chilomonas

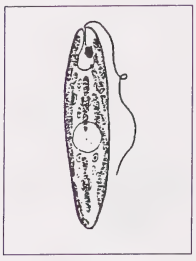

Chlamydomonas

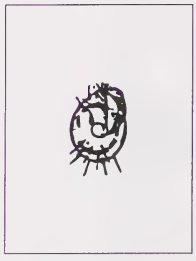

Coleps


Colpoda

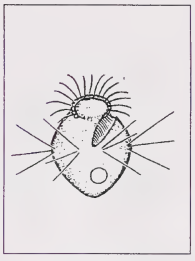

Didinium


Eudorina


Euglena

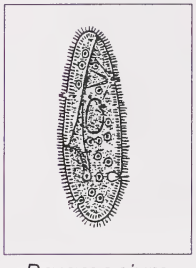

Euplotes


Gonium

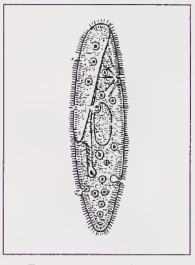

Halteria


Loxodes


Oxytricha


Paramecium Aurelia


Paramecium Bursaria


Paramecium Coudata


Paranema


Spirostomum


Stentor


Stylonychia

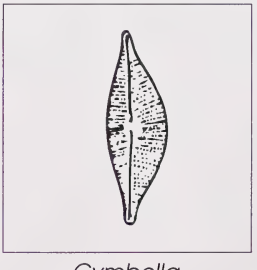

Volvox

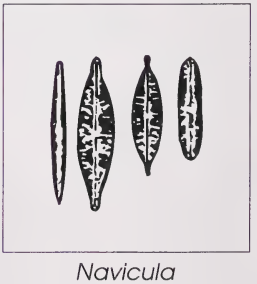

Vorticella

Diatoms (Bacillariophyceae)

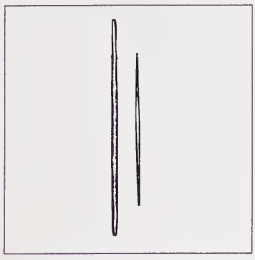

Achnanthes


Amphora


Cymbella


Navicula

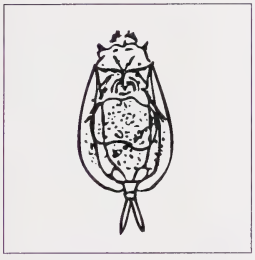
Pinnularia



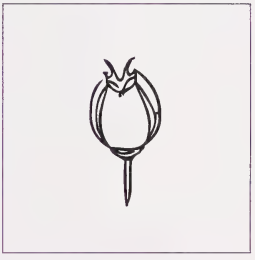
Synedra

Rotifers

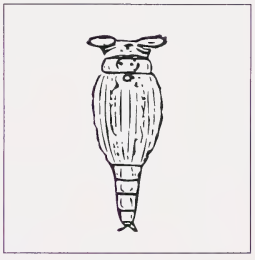
Ephiphanes



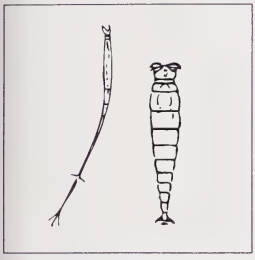
Euchlanis



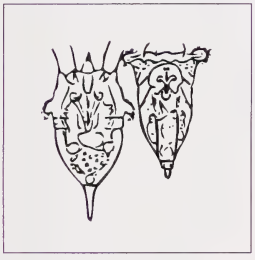
Lecane



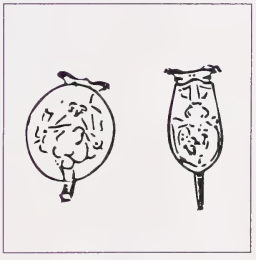
Philodina



Rotaria



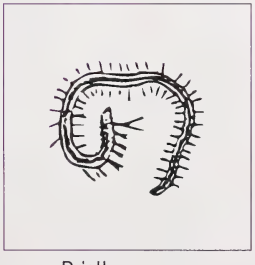
Synchaeta



Testudinella

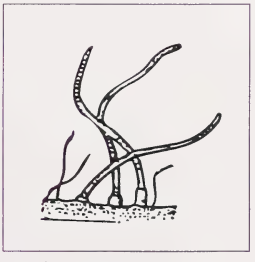
Miscellaneous Invertebrates

Gasterotrich,
Chaetonotus



Bristle-worm

Nematode Worm



Sewage Worm,
Tubifex

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Science 20

Student Module Booklet

Module 4

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